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INDEX TO ARTICLES

(Items to which asterisks (*) are affixed are "Notes on Engineering and Applied Science," containing 400 words or less.)

AERIAL NAVIGATION.

Aeroplane Design 391
Lift of Aeroplanes* 648
Second International Aeronautic Race..... 60

AUTOMOBILES.

Gear Arrangements and Ratios in Motor Cars..... 287
Notes on Motor-Car Design..... 605
Producer-Gas Motor Car* 523
Use of Glycerine in Radiators* 413

CHEMISTRY AND PHYSICS.

Ethereal Energy* 523
Fog and Its Mitigation* 295
Gravitation, Cohesion, Adhesion: A Theory to Account for their Identity..... 57
International Atomic Weights* 412
Investigations on Radium..... 500
Lumière Autochrome Plate..... 68
The Newer Chemistry..... 67

CIVIL ENGINEERING.

Bridges:
- Erection of Manhattan Bridge across East River.. 241
- Proposed Henry Hudson Memorial Bridge..... 34

Buildings:
- Can Earthquake-Proof Buildings be Erected?.... 173
- The Singer Tower and the City Investing Building, New York City..... 1

Cableways, Construction and Operation of..... 253
Chimneys, Design of Reinforced-Concrete..... 482
Columns:
- Crippling Strength of Bridge Compression Members. 137
- Design of Struts..... 265
- Relative Strengths of Carbon-Steel and Nickel-Steel Columns 252

Concrete:
- Artistic Concrete for Residences..... 121
- Tree Dentistry 137

Corrugated Steel Sheets, Strength of* 185
Dams:
- Construction of the Laguna Dam, Colorado River.. 361
- Stresses in Dams..... 246

Fireproofing Woods and Fabrics* 64
Reinforced Concrete:
- Ferro-Concrete 269
- Joining Old Concrete to New* 185
- New Reinforced Concrete Regulations in Phila... 139
- Notes on Reinforced Concrete Work..... 378
- Reinforced Concrete for Fire-Resisting Buildings. 179
- Sound Concrete Construction 122
- Structural Steel vs. Reinforced Concrete..... 155
- The Mushroom System of Reinforced Concrete.... 147

Riveted Joints, Strength of..... 142
Roof Trusses, A Study of..... 285
Tunnel, Opening of the First Hudson River..... 395
Water, Flow of:
- Flow of Water in Open Conduits..... 129
- Mean Stream Flow Estimates* 647

Waterproofing:
- Effect of Alum and Clay in the Waterproofing of Concrete* 412
- Waterproofing Concrete Structures* 291, 407

Wind Pressure, Recent Experiments on..... 243

ECONOMICS AND EDUCATION.

A Novel Fire Detecting Service* 412
Engineering Education in Germany* 524
Industrial Education 645
Origin of the Word "Ingenieur"..... 646
Technical Education in America..... 644
The American Patent System..... 638
The Field of the Mechanical Engineer..... 10
The Work of the Forest Service..... 597

ELECTRICAL ENGINEERING.

Belt Electricity* 295
Clutches, Calculations for Magnetic* 647
Choking Coils, Calculations for..... 629
Hygienics of Gas and Electricity* 649
Electric Motors, the Use of Ball Bearings on..... 261
Electric Welding by the Benardos Process..... 244
Electromagnets, Calculations for Plunger..... 56
Illumination:
- Color Values of Artificial Lights* 64
- Comparative Costs of Illumination* 524
- Device for Illuminating Harbors..... 266
- Effect of Light on the Eye* 292
- Incandescent Lamp Tests, Recent..... 519
- Metal-Filament and Carbon-Filament Lamps..... 642

Insulation:
- A New Insulating Material* 412
- Cellulose Acetate for Wire Insulation* 295

Lightning, The Protection of Buildings from.... 165
Magnetic Alloy for Transformers, etc.*..... 523
Resistances, The Design of Water..... 275
Tinol* 64
Turbo-Generators, Continuous Current..... 173

INDUSTRIAL TECHNOLOGY.

Alcohol:
- Alcohol from Natural Gas* 524
- Alcohol from Peat* 647
- Bibliography of Books and Articles on Heating, Lighting and Power Development by Means of Denatured Alcohol 495, 609

Coal Tar, Disposal of..... 635
Creosoting Douglas Fir..... 410
Graphite, Manufactured* 65
Monox* 64
Oxygen in the Arts* 65
Wood. Distillation 160

MARINE ENGINEERING.

Air Pumps and Condensers..... 364
HP. Measurement of Marine Steam Turbines..... 393
Influence of Air on Vacuum in Surface Condensers. 636
Use of Lime in Boilers..... 640

MATERIALS OF ENGINEERING.

Cadmium and Its Uses* 65
Cast Iron:
- Cast Iron Mixtures, Calculation of..... 177
- Physical Characteristics of Cast Iron..... 250
- Vanadium in Cast Iron* 414

Cement:
- Calculating Portland Cement Clinker..... 622
- Classification of Cements..... 25
- Economical Production of Portland Cement by the Use of High-Magnesian Limestone..... 487
- Hydraulic Properties of Reground Cement Mortars. 176
- Influence of Gypsum and Chloride of Calcium on the Setting of Portland Cement..... 385
- Irregularities in Cement Analysis* 649
- Manufacture of Commercial Portland Cement..... 247
- Setting of Portland Cement..... 135
- Tests of Portland Cement and Cement Mortars.... 518

Concrete:
- Bond Between Plain Steel Bars and Concrete..... 180
- Durability of Concrete* 186
- Effect of Mica on Concrete* 294
- Efflorescence on Concrete* 185
- Manufacture of Blast-Furnace Slag Brick..... 515
- Protective Action of Concrete on Steel* 523
- Tests on Concrete for Heat Resistance* 297

Ferro-Alloys for Foundry Use..... 16
Iron, Rusting of.....296*, 477
Malleable Cast Iron..... 511
Malleable Cast-Iron "Steel"* 292
Molding Sand, Ideal* 292
Phosphor-Bronze 376
Steel:
- Preservation of Steel Imbedded in Concrete* 298
- Strength of Cold-Drawn Steel Bars* 291

Stone, Treatment of Decayed* 298
Testing Iron and Steel:
- An Instrument for Testing Hardness* 66
- Electromagnetic Hardness Tester..... 631
- Hand Bending Tests of Materials..... 475

Wood:
- Moisture and the Strength of Wood* 413
- Shrinkage of Wood* 648
- Strength of Wood* 293

MECHANICAL ENGINEERING.

Boilers and Furnaces:
- An Efficient Steam Boiler* 185
- Economizers 388
- Radiation Law, Stefan and Boltzmann's..... 54
- Ratio of Heating Surface to Grate Surface as a Factor in Power-Plant Design*..... 293

Compressed Air:
- Compressed Air and the Kinetic Theory of Gases.. 45
- Compressed Air Calculations..... 505
- Flow of Compressed Air in Pipes..... 480

Elevating Material, Power Cost of* 185
Feed Water:
- Live-Steam Feed-Water Heating* 413
- Water for Economical Steam Generation* 293
- Water Treatment with Barium Salts* 206

Founding:
- Electric Furnaces for Iron and Brass Foundries... 517
- German Cupola Practice* 292

Fuels:
- Advantages of Producer-Gas Firing..... 264
- Burning Pulverized Coal* 186
- Flue-Gas Analysis: Its Value..... 33
- Use of Peat as an Economical Fuel* 291
- Utilization of Fuels..... 626
- Weathering of Coal..... 380

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Heating:
Austrian Heat Coefficients for Building Materials. 406
Heat Insulating Materials. 290
Internal-Combustion Engines:
Control of Internal Combustion in Gas Engines. 6
Destruction of Tar in Gas Producers. 383
Exhaust Gases from Petrol Motors. 175
Fuel Consumption in Producer-Gas Plants. 521
Gas Engines and Indicators. 22
Governing and Regularity of Gas-Engines. 614
High-Efficiency Oil Engine* 647
Measuring Gas-Engine Temperatures. 263
Recent Gas-Engine Efficiency Tests. 286
Lubricant Testing Machine, A New*. 413
Machine Design:
Design of Machinery Bearings. 130
Friction Losses in Countershafting* 64
Power Transmission by Friction Driving. 145
Progress with Ball and Roller Bearings. 61
Steel Belts for Power Transmission* 648
Strength of Chain Links* 650
Strength of Flanged Fittings* 185
Strength of Rings* 186
Metal Working:
Cutting Speeds of High-Speed Tools* 291
Heat Stresses and Cracks in Boilers. 282
Riveting vs. Welding 411
Piston Speed and Steam Engine Economy. 643
Power Hammers, Steam vs. Compressed Air for*. 650
Power Plant Costs, Steam-Driven Electric. 144
Pumps for Liquids*. 291
Refrigeration, Chloride of Calcium in. 62
Steam Pipe Systems for Generating Stations. 373
Steam Turbines:
Combination System of Reciprocating Engines and Steam-Turbines 641
Exhaust Steam Turbines 509
Notes on Steam-Turbine Engineering. 520
Superheated Steam .143, 408, 648*
Specific Heat of Superheated Steam.24, 521
Water Power:
Economic Value of Water Power. 619
Speed Regulation of High-Head Water Wheels. 380

MINING AND METALLURGY.

Breathing Apparatus for Use in Mines* 297
Cyanidation, History of. 151
Detinning Scrap 276
Dry Air Blast 513
Electric Smelting of Iron Ores. 600
Electro-Thermic Production of Iron and Steel. 277
Fires in Mines: Extinguishment by Sulphur Dioxide. 409
Iron and Fuel, Specifications for. 287
Rolling Mills, Electric Driving of. 623
Steel, Diamond and Carborundum Crystals in* 294
Steel Making, Duplex Process for. 260
Zinc, Metallurgy of* 523

MUNICIPAL ENGINEERING.

Refuse Disposal, A Study of. 168
Roads:
Automobile Street Sweeper* 647
Density of Pavement a Factor in Its Durability*. 294
Mixtures for Sprinkling Road Surfaces* 185
Modern Construction of Macadamized Roads. 367
Problem of Road Construction, The. 603
Sanitation:
Importance of Sulphur Dioxide in the Atmosphere*. 291
Sanitary Engineering 37
Water Supply:
Purification of Drinking Water.52, 483
Small Water Supplies 399
Sterilization of Drinking Water.412,* 501, 523*

RAILROAD ENGINEERING.

Block Signals, Automatic 17
Canal-Boat Haulage* 412
Car Wheels, Slipping of Steel and Cast-Iron. 522
Locomotives:
Application of Highly Superheated Steam to Locomotives 29
Combustion and Heat-Balancing in Locomotives. 621
Fireless (Steam Accumulator) Locomotives. 503
Notes on Steam Locomotive Design. 394
Performances of Steam and Electric Locomotives. 47
Track Brake, A New Electromagnetic* 64

BIOGRAPHICAL.

M. N. Forney. 184
Dr. John Galbraith, President Can. Soc. C. E. 289
Lord Kelvin 63
Presidents of Four National Engineering Societies: Charles Macdonald, C. E.; M. L. Holman, M. E.; John Hays Hammond, E. M.; H. G. Stott, E. E. 181

BOOK DEPARTMENT.

Articles:
Pratt Institute Free Library: Its Department of Technical Literature 187
The Value of English to the Engineer. 299

BOOK REVIEWS AND NOTICES.

Aerial Navigation:
Airships, Past and Present—Hildebrandt. 653
Flying Machines—Marshall 74
Architecture:
Bungalows, Camps and Mountain Houses. 653
How to Read Plans—Peker. 421
Chemistry:
Electro-Analysis—Smith 73
Engine-room Chemistry—Gill. 72
Textbook of Electro-Chemistry—Le Blanc. 417
Thermodynamics of Technical Gas Reactions—Haber 651
Civil Engineering:
Analysis of Elastic Arches—Balet. 415
Concrete—Godfrey 527
Engineers' Handbook of Concrete Reinforcement. 420
Field System—Gilbreth. 189
Methods for Earthwork Computations—Crockett. 651
Moving Loads on Railway Underbridges—Bamford. 419
Practical Design of Irrigation Works—Bligh. 191
Practical Earthwork Tables—Heusden. 653
Retrieval at Panama—Bates. 303
Specifications and Contracts—Waddell & Wait. 70
Structural Steel Tables—Godfrey. 72
Tables of Quantities for Preliminary Estimates—Hauch and Rice 74
Electrical Engineering:
Alternating Current Motors—McAllister. 69
Colorado Springs Lighting Controversy—Floy. 528
Electrical Instruments and Testing—Schneider. 420
Experimental Electrical Engineering—Karapetoff. 305
Four-Year Topical Index to the Electric Journal. 421
Introduction to the Study of Electrical Engineering—Norris 417
Standard Handbook for Electrical Engineers. 188
Wireless Telegraphy for Amateurs—Howgrave-Graham 306
Wireless Telephony—Ruhmer. 419
Industrial Technology:
Chemistry of Gas Manufacture—Royle. 304
Industrial Alcohol—M'Intosh. 70
Practical Handbook on the Distillation of Alcohol from Farm Products—Wright. 190
Mining and Metallurgy:
Dredging for Gold in California—Weatherbe. 418
Metallurgy of Iron and Steel—Stoughton. 416
Mining, Mineral and Geological Law—Shamel. 305
The Electric Furnace—Stansfield. 529
Mechanical Engineering:
Elevator Service—Bolton. 529
Hydraulics—Dunkerley 71
Hydraulics—Lea 526
Mechanical Engineer's Reference Book—Suplee. 73
Power and Transmission—Kerr. 418
Practical Steam and Hot Water Heating and Ventilation—King 416
Refrigeration—Anderson 652
Steam-Electric Power Plants—Koester. 526
Tool Making—Markham 75
The Gas Engine—Hutton 419
The Gas Engine in Principle and Practice—Goldingham 420
The Steam Turbine—Neilson. 527
Municipal Engineering:
Disposal of Municipal Refuse—Parsons. 189
Garbage Crematories in America—Venable. 190
Land Treatment of Sewage—Scoble. 306
Methods and Devices for Bacterial Treatment of Sewage—Venable 525
Practical Hydraulic (Water Supply and Drainage) Tables and Diagrams—Park 652
Sanitation of Public Buildings—Gerhard. 69
Water Supply—Turneaure 418
Railroad Engineering:
Economics of Railway Operation—Byers. 302
Elements of Railroad Engineering—Raymond. 525
The Motorman and His Duties—Gutman. 74
Miscellaneous:
Engineering Reminiscences—Porter. 528
How to Use Slide Rules—Petri-Palmedo. 652
Mathematical Handbook—Seaver 73
Men Who Sell Things—Moody. 306
Metric Weights with English Equivalents—McCartney 191
Structural Drawing—Edminster 420
Technological Dictionary—Tolhausen. 528
NEW BOOKS.75, 191, 306, 421, 530, 653
INDUSTRIAL ENGINEERING: A Record of New Tools, Processes and Appliances. 77, 193, 309, 423, 531, 655
NOTES ON ENGINEERING AND APPLIED SCIENCE.64, 185, 291, 412, 523, 647
THE TECHNICAL PRESS INDEX: A Classified Descriptive Listing of Technical Articles in Current Periodical Literature. 83-118, 201-240, 313-360, 427-474, 537-596, 663-714
TRADE CATALOGS AND PAMPHLETS. 81, 199, 311, 426, 535, 658

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THE ENGINEERING DIGEST

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TWO NEW RECORD-BREAKING OFFICE BUILDINGS IN NEW YORK CITY

THE SINGER TOWER AND THE CITY INVESTING BUILDING

SLIGHTLY CONDENSED FROM "ENGINEERING NEWS"

There has rarely been a period of more than a few months in the last decade when the "largest office building" was not in process of construction in New York City. So rapidly has the erection of these immense skyscrapers progressed that the interest in the latest one has usually not been more than a matter of passing moment or an object of interest to the sightseeing tourist.

At present, however, there are four record-breaking buildings under construction in New York City, the Metropolitan Life tower, the Church Street Terminals, the Singer tower and the City Investing Building. The first of these will have the highest tower in the world, except the Eiffel Tower; the second will have the largest floor area ever found in an office building; the third, the Singer tower, while a few feet lower than the Metropolitan Life Tower, will be finished some months before the latter and therefore for a short time will hold the record for height and the City Investing Building will be the tallest building which carries the major portion of its area to its maximum height.

The half-tone reproduced in the accompanying illustration is from a photograph taken on Nov. 8, 1907, from the offices of Engineering News on the 19th floor of the St. Paul Building, about 200 ft. from the ground. The view is down Broadway and shows in the foreground, first the 32-story City Investing Building at this time about 25 stories high, and behind it the 41-story tower of the Singer Building, practically completed. These two buildings, which will be finished about the same time, cover most of the block enclosed by Broadway, Liberty street, Cortlandt street and Trinity Place. They are being built by separate companies under separate contracts to different firms, and although they are not alike in any of the details of their construction, their simultaneous erection on adjoining lots and the magnitude of the operations involved in their construction, lends to them a companion interest. For this reason we have treated the two in this one article.

SINGER BUILDING.

The new Singer Building is a combination of two old steel frame buildings on the corner of Broadway and Liberty St. with an adjoining new structure fronting on Broadway and extending back to the same depth as the two old lots. The old buildings, originally 11 stories, have been raised to 14 stories and the new structure consists principally of a 41-story tower with a four tier lantern which rises to a total height of 612 ft. above the sidewalk, some 46 ft. lower than the Metropolitan Life tower (see page 114, vol. I., Technical Literature), but otherwise the highest piece of construction on this side of the ocean. The architectural treatment of the new portion has been made to harmonize with the old, a particularly ornate design with a red facing wall trimmed with white stone window casings and cornices.

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The slender square tower, with its gracefully tapering cupola and tall lantern lookout, rising far above the mass of high buildings of lower Manhattan, adds a striking landmark to that already picturesque skyline.

There is a total floor space in the building of 9½ acres, there being 20,000 sq. ft. available on each of the 14 floors of the main portion and 3,300 sq. ft. on each of the tower floors, in no one of which are there any inside rooms. There are four elevators rising to the fourteenth floor and four more to the 35th floor, which is the last floor in the square section of the tower. Above this the curved cupola rises to the 40th floor, at which point the lantern starts. There are really 48 so-called tiers or levels of horizontal beams, this including certain mezzanine floors and the small area landings in the lantern.

The entire building is of skeleton steel construction, fireproofed with terra-cotta tiling and provided with terra-cotta floor systems surfaced with cement. The columns are founded on concrete footings sunk by compressed air caissons some 90 ft. below street level to bed rock. Except in three cases these concrete footings are arranged so as to each carry a pair of columns, the load being distributed from the column through cast steel bases to a single I-beam grillage, made up in some cases of I-beams as large as 24 ins.

The customary practice is followed by placing the concrete footing and I-beam grillage so that the differing loads on the two columns will center over the center of gravity of the footing. In two of the three cases where a single column bears on a footing, small circular caissons were driven and in none of these three was an I-beam grillage used, the steel castings resting directly on the concrete.

The structural details of the main 14 stories have nothing out of the ordinary. The columns are spaced uniformly at 12 ft. c. to c., connected at right angles by I-beam wall and floor beams. The corners and elevator shafts are wind braced with diagonals as described below, but there is no horizontal floor or wind bracing. The columns are made up of a double channel section, enlarged, where needed, by the addition of flat plates. The largest column consists of two 15-in. channels, four 20 × ⅞-in., two 20 × ¾-in., eight 14 × $^{13}/_{16}$-in. and two 12 × ½-in. plates, a total section of 235 sq. ins. for a total load of 3,400,000 lbs. These columns have a standard length of 13 ft. 4 ins. between floors. The outside columns stop at the 36th floor, above which outside walls are carried on curved double-channels; the inside columns still continuing. Above the 40th floor the lantern construction is carried up with light angle columns to a smaller cupola formed with curved angle columns. A steel flag-pole, shown in the illustration, passes through the hole in the very top of the cupola and is anchored in a socket at the 43d floor.

The wind bracing on the tower is of extraordinary interest. On account of the small section of this tower and the necessity for as much window space as possible it was deemed inadvisable to cross-brace the entire structure or even its entire faces. The plan of the tower is divided symmetrically into 25 squares each 12 ft. on a side, by columns running from foundation to the beginning of the cupola. The tower is wind braced and stiffened by treating each one of the corner squares as a separate tower and bracing it on all four of its sides by crossed diagonal struts. In addition the three closed sides of the elevator shafts are treated in a similar manner.

The exterior bracing is arranged differently on account of the necessity for openings. This consists of a long and a short panel, each cross-braced and with the horizontal members coming between floors. The windows then occur in the openings of the large panels. The bracing throughout consists of double crossed channel beams, with their flanges facing in the same direction, one of each set being cut and passing the other with a riveted plate. Above the 36th story no wind bracing was provided.

In designing the wind bracing in this manner, that is, in assuming each of these small 12 × 12-ft. towers to be independently capable of taking wind stresses, a theoretical uplift is exerted on each of the bases of the columns at the corners of the braced towers. To provide for this uplift, these columns were anchored into the concrete caissons on which they rest. All of the outside columns carry an extra dead load due to the weight of the brick walls largely exceeding the uplift from the wind and therefore no anchors were provided for them.

Each anchorage consists of a small angle-iron grillage embedded in each one of the caissons as it was built and in such a position that when the caisson reached its bearing the grillage would be at approximately an elevation 60 ft. below datum. To this grillage there were fastened flat plates increasing in number and in size as they neared the top of the con-

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Die Kirche in Wilmersdorf. Architekt Otto Kerwien.

two round rods 3½ ins. in diameter in four of the columns, and 4½ ins. in diameter in the other anchorages. These rods pass by the grillage between the I-beams and outside the cast-steel bases up to a saddle riveted to the column.

This saddle consists of a block, spanning the heavily plated ribs which are riveted up the column for a distance of from three to five feet, varying on the different anchorages. These saddle blocks are notched on both sides so as to engage with similar lugs on the ribs and thus make a firm, immovable bearing.

In those columns, where the span blocks have but two vertical ribs, a lower lug or projection is provided to give additional strength. The anchor rods pass through these blocks and are fastened thereto with nuts and washers which are easily accessible and can be inspected and tightened at any time.

Up to the present, when the entire steel work is finished and the brick face walls up to within a few stories of the top, this system of wind bracing has proved remarkably efficient; the tower is one of the stiffest steel structures in New York City.

The steel construction is in many ways peculiar, particularly in the treatment of the wind stresses. There has never been an exactly similar solution of the problem, although it is true that there has never been precisely this same problem of a very high and slender steel tower used for office purposes.

Throughout the work it is evident that it is an architect's design in which structural detail has been subordinated to architectural considerations This is noticeable in the trumpet arch construction at the 34th floor just below the bay windows of the upper cupola. This has the appearance of a stone arch capable in itself of sustaining its own thrust but in reality the overhang was so great that the consulting structural engineers required a series of cantilevered beams to be built out above the arch and each voussoir to be hung from a beam by rods wedged into dog holes cut in the upper face of the stone. As the abutment of this heavy arch was originally only an 18-in. stone, the design was, at least, bold.

The Singer Building is being erected by the Singer Manufacturing Co. The architect is Mr. Ernest Flagg, to whom is due the entire design and supervision of the structure. Messrs. Boller and Hodge are consulting engineers on the structural work. The Foundation Co. of America had the foundation contract and Milliken Bros. the structural steel work.

CITY INVESTING BUILDING.

This building occupies the entire frontage of the south side of Cortlandt St., between Broadway and Trinity Place, but owing to difficulties in obtaining the corner property at Broadway and also to the architectural treatment of the light shafts, which are recesses in the front of the building instead of the usual interior shafts, the plan of the building is singularly irregular. The main building rises to a height of 25 stories, capped on the narrow Broadway front by a small tower, and that portion between the Cortlandt St. wings reaches, for a section about 70 ft. square, to a height of 32 stories, the last three stories of which are in a sloping gable, rising about 400 ft. above the street. It is of the usual steel construction, faced with white stone for the first six stories and above that with white brick and terra-cotta trimmings. The most striking architectural feature of the building is a three-story arcade which extends from the Broadway front clear through the building to Trinity Place. This arcade opens into Broadway in a magnificent arched portal, the artistic treatment of which makes it one of the finest entrances ever placed in a building of this sort.

Owing to the proximity of existing buildings and to the simultaneous erection of the adjoining Singer Building, some portions of the old parts of which had to be underpinned, considerable difficulty was experienced in laying the foundations. The column footings were all carried down from the basement level, about 30 ft. below the street, to a few feet below hard pan, by the use of compressed air caissons filled with concrete. Each of the interior columns foots on a single square concrete base for which small caissons were used. As the wall columns rested on grillages which cantilevered over from adjacent footings, these latter were much larger and rectangular in shape. The steel bases and cantilever girders which carry the columns are described below.

The structural features of the building do not vary from ordinary practice in many instances. Some of the details which are unique or worthy of description on account of their magnitude are noted below. In general the structure consists of columns spaced about 22 ft. c. to c., connected in the walls and in the main girders by floor girders of twin I-beams which in turn are connected by single floor beams of I section. The first two floors are each 22 ft. high and above that the floor spacing is 14 ft. All the plan layout is rectangu-

lar with the exception of the peculiar radial beams at the elevator shaft and the corners of the Cortlandt St. wings. The special points of interest in the design are the heavy foundation bearing-girders, the cast-steel shoes, the bracing over the arcade, the wind-bracing and the columns; the latter on account of the reawakened interest in large columns since the fall of the Quebec Bridge.

The immense girders on which the outside columns rest are founded on I-beam grillages set in the concrete of the caisson-filled footings. A cantilevered column bearing is used at the inside face of the building where the adjoining foundations of the Singer Building prohibited the sinking of caissons.

These girders are made up of three heavy plate girders, 84 ins. deep with flanges of 8 × 8-in. angles and two ⅞-in. plates and a web of one ⅝-in. and two $^{5}/_{16}$-in. plates. They are heavily stiffened under the columns with 6 × 3½-in. angles. The girders are bedded in cement grout on the I-beams. The columns rest on steel castings resting in turn on hot pressed plates on the girder upper flanges.

The footing girders at the Broadway wing under the arcade are the largest footing girders used in the building. They are made up of three plate girders, each 96 ins. deep, with a web of one ½-in. and two $^{5}/_{16}$-in. plates and flanges of 8 × 8-in. angles with three 1-in. cover plates. Their general details are similar to the cantilevered beams noted above, but owing to the two columns being so close together, the ends of the girders are provided with extra heavy stiffening.

The interior columns are founded on single grillages, made up of one or two crossed I-beams carrying a cast steel shoe. The smaller of these shoes were cast in one piece as is the customary practice, but owing to the danger in casting and the liability of shrinkage cracks in large masses, the heavy castings were made in two pieces.

These latter consist of two separate webbed castings, each planed on both horizontal faces and bolted together so that the general pyramidal shape will spread the stresses to the concrete footings. These separated castings have given the greatest satisfaction, there has not been the slightest trouble in casting and the details of setting and moving have been greatly simplified over the methods in use in similar single castings.

On account of the arcade through the building, the Broadway wing above the third floor is carried upon plate girders spanning the arcade and resting on extra heavy side columns. The side columns, founded on the grillage, are formed of two regulation section columns, acting as one, tied together beneath the first floor by a lacing and from the first to the third floor by a diaphragm plate. The third floor, with its bearing columns, is carried upon these side double columns on a plate girder about 32 ft. long and 87 ins. deep, made up of flanges with 8 × 8 × ⅞-in. angles and two ¾-in. plates and of two ½-in. webs, riveted to opposite sides of each flange angle. These girders are braced together by a heavy truss made up of I-beams and angles. A curved bracket transmits the reaction into the columns.

The wind stresses are taken up by an increased rigidity of the rectangular connection between the wall columns and beams. That is, the inside half of the flanges of each twin I-beam is cut away where the beams cross a wall column and the web of the beams riveted, with as many rivets as the area will take, to the vertical side plates of the column. Horizontal stiffening plates are then riveted to the remaining half of the floor beam flange to make up for the material removed. This makes a remarkably stiff connection capable in itself, without the use of any other diagonal or knee bracing to take up wind stresses. This method has been previously used by the consulting engineers on the Trinity Building with great success in stiffening the structure. The largest section of one of the typical heavy columns used from the sub-basement to the 32d floor, is that at the sub-basement; it has a maximum area of 253.6 sq. ins. to carry a load of 1,719 tons. In the design of this column, wherever a change in section occurs, the superposed column always has at least its own full area to bear upon; that is, the taper is on the outside and only in a few instances does the section span an opening in the one next below it. The building is being erected, at an estimated cost of $10,000,000, by the City Investing Co. of New York. The architect is Mr. Francis H. Kimball, the consulting structural engineers Messrs. Weiskopf & Stern, and the general contractors the Hedden Construction Co. The O'Rourke Engineering Construction Co. put in the foundations and the steel work is being erected by Messrs. Post & McCord. The building is expected to be ready for occupancy by May, 1908.

CONTROL OF INTERNAL COMBUSTION IN GAS ENGINES*

By PROFESSOR CHARLES EDWARD LUCKE

One of the primary prerequisites for close engine control or regulation, be that engine a steam engine, a gas engine or any other kind of motor, is absolute constancy of cyclic effort with a fixed position of the controlling mechanism. The promptness with which a change of effort will follow a change of setting of the governing or regulating gear depends among other things upon the cycle of operations to be carried out in the cylinder, and, in the case of gas engines, the cycle is such that much time may elapse between a governor movement and the controlling effect desired. This has been clearly pointed out in many papers and as ordinarily called "cyclic influence" it is well understood.

It is the object of this paper to examine into the conditions under which constancy of effort may or may not be obtained with constancy of setting of the governor and valve gear. It is possible in gas engines to get many different indicator cards at apparently constant external load, the differences indicating differences of effort and in most gas engines, even with the mechanism for controlling the engine fixed in position, the same variation of indicated effect may be observed. The differences which will appear on the indicator card for apparently identical conditions are not differences in compression, suction or exhaust lines, but almost entirely differences of combustion and expansion lines, or as the expansion line position is fixed by the combustion line, it may be said that the differences are due entirely to variations in combustion lines.

It would appear, therefore, that because combustion lines in gas engines are not identical for apparently identical conditions of the mechanism that we have failed to control this combustion in a manner required by everyday practice in the use and application of gas engines. Whether, however, this failure is due to ignorance on the part of designers, or whether the end sought is in opposition to natural phenomena, will not appear without analysis.

An examination of the indicator cards here presented and many others of a similar kind that every gas engine experimenter has found at some time or other will indicate that the variations in the combustion line are principally of three sorts, running one into the other; first, there may be too early a beginning of the combustion line or preignition, which comes and goes sometimes in the most puzzling fashion, but which at other times can be traced to a removable cause and eliminated; secondly, with an absolute constant ignition and smooth lines successive strokes may indicate a displacement of whole or part of the combustion line. This is a mixture variation effect. Thirdly, there may be at some time violent waves or even mild waves differing on successive strokes, passing away and recurring at times, and at other times persistently present. This is the phenomenon of the explosive wave.

MIXTURE EFFECTS.

A variation of mixture may affect the combustion line through a change in the rate of propagation, which results from changes in mixture proportion considered in conjunction with piston speed. A slow burning mixture will tend to give a flatter combustion line with a fixed piston speed than a fast mixture. Likewise, a mixture may begin to burn rapidly and finish slowly, giving succeeding combustion lines which coincide in part, but which vary toward the end where the combustion line runs into the expansion line from the dilution of the last part of the charge by early produced neutral gases. Through excessive dilution of some part of the mixture in the cylinder, which it must be understood is probably not homogeneous, some of the gas may not burn and on succeeding strokes the diffusion may be more or less complete than before, allowing the incompleteness of the combustion to vary toward the end of the process. The actual mixture under combustion consists not merely of air and gas, but rather air, gas and burnt or neutral gases. Any variation of proportion of the quantity of air, gas or burnt gases to the whole that may occur will produce variations in combustion lines, but variations

*From a paper presented at the New York Meeting (December, 1907) of The American Society of Mechanical Engineers.

in combustion lines may just as well occur when the proportions of totals are constant, through lack of homogeneity of the mixture on successive strokes.

Excluding for the moment a consideration of neutral products the problem of securing a proper proportion of air to gas in the cylinder is one of orifice flow, and the failure to secure it may be analyzed on the basis of the laws covering orifice flow. In this connection it must be remembered that it is not volume proportions that are most important, but rather weight proportions, since it is a definite weight of air that is required to burn a definite weight of gas, although volume proportionality will follow if the pressure and temperature of both the air and the gas are constant and the same, which unfortunately is seldom true. The orifices through which the air and gas flow separately to form the mixture are of very peculiar forms, as a rule, and not the same either in size or form so that the laws of variation of proportion are reducible to the laws of variation in the weight of air per pound of gas flowing through separate orifices of different form and size at probably different temperatures and with different pressure drops or pressure heads.

It is well known that the coefficient of efflux for the flow of gases through orifices varies with the size of opening, shape of opening and velocity of flow or pressure head. Air enters the engine cylinder under the influence of a pressure head represented by the cylinder vacuum. The gas, however, has a pressure higher than atmosphere if pressure gas and lower than atmosphere if suction producer gas, so that while the head causing the flow of air is the cylinder vacuum alone, the head causing the flow of gas when under pressures is the sum of the cylinder vacuum head and its own pressure head, and when under suction is the difference between the cylinder vacuum and the gas pipe vacuum. Gas pressures are, moreover, never constant in practice nor will any of the gas pressure regulators proposed and used make them constant nor reduce them uniformly to atmosphere because they always involve inertia effects of moving solid parts and of the gas itself.

With a fixed opening the cylinder vacuum head acting on the orifices is a variable because piston speed in engines varies from zero to a maximum and back to zero for every suction stroke. This variable vacuum head with fixed gas pressure head either positive or negative causes a variation in the ratio of the total head on the gas orifice to the total head on the air orifice and hence has the effect on varying proportions of air to gas throughout the stroke. In addition to this, whenever the gas is under pressure, and the opening fixed, the idle engine period, that is, the period of no suction, allows time for the pressure gas to flow past the orifice and collect in the air chamber, which would tend to make the mixture rich in gas at the beginning of the next stroke.

Intermittence of flow is another element which enters into the variation of proportion because it brings into play the inertia of the gas and the inertia of the air. A stream of air or gas cannot be started or stopped instantly, and as the masses to be moved are not the same the inertia will not be the same for the two, and one will tend thereby to lead in its flow over the other one, that which has the smaller mass leading. At the end of suction that which has the greater mass will continue its motion for the longer time.

It appears, therefore, to be an extremely difficult proposition, viewed entirely independent of the gas engine, to secure constant weight proportion between two gases flowing through two orifices into a partial vacuum through openings of different sizes and shape under heads compounded of the vacuum and the gas pressure with variable rates of flow, changes of barometer, gas pressure and the temperature of both gases and it is not surprising that variations occur, but rather more surprising that the results are as uniform as they are. After having proportioned the air and the gas, the mechanism delivers it into a cylinder through a valve to an irregular head or clearance space where it mixes more or less uniformly with the neutral gases there. These residual gases may have the same composition on successive strokes or may not, depending upon a variety of circumstances, some uncontrollable, such as diffusion, others under practical control, such as point of ignition and back pressure. It is to be distinctly understood that the mixture variations which occur in a hit-and-miss governed engine, before and after misses when the combustion chamber contains in the one case air after a miss and in another case burnt gases after an explosion, are excluded from this discussion and only the variations which occur in engines operating under steady and uniform conditions included.

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EXPLOSIVE WAVES.

The French scientist, Berthelot, gave the name "explosive wave" to a certain phenomenon observed in the combustion of explosive mixtures, which phenomenon was later more fully investigated by Mallard and Le Chatelier in "Recherches Experimentales et Theoriques sur la Combustion des Melanges Gazeux Explosifs," and in recent years by Dixon and Bradshaw, Crussard and many others, which phenomenon may easily occur and does occur in gas engine cylinders. In some cases it is possible to define the conditions which will produce it and in other cases it is not. Examining the rate of propagation through a tube it is found that at times the propagation is uniform, at times mildly undulatory, indicated by waves of small amplitude, and at times violently undulatory, indicated by waves of great amplitude accompanied by shock and sound. This violently undulatory propagation has an extremely high rate and can be produced whenever there is a violent agitation of the mixture about to be ignited.

One sort of agitation producing this result and in use by early experimenters was a small stream of the mixture impinging into the main mass. An apparently different agitation though probably identical, studied especially by later experimenters is a pressure wave or compression wave. It can be shown that if combustion be started in a tube, closed at one end, waves may set up so violent as to cause extinction before the passage through the tube is completed. In this case the agitation is a result of a compression wave produced by the combustion itself. In engine cylinders this same sort of wave may exist. The motion of the piston itself during compression produces a compression wave which advances before it through the mixture and which probably reflects and superimposes or neutralizes, as accident may dictate, so that the entire mass is in a process of agitation during compression.

Inflammation started in such a mixture agitated either by streams of gas as the result of pockets in the combustion chamber or by compression waves, will sometimes be very violent, giving a true explosive wave, but may not exist at all. This seems to indicate that the violent momentary pressures of the explosive wave crest result only, when advancing waves superimpose one on another and synchronize with their reflections.

A simple experiment that can be performed by anyone will yield explosive waves of this sort on any gas engine if between the indicator and the engine cylinder there be connected a pocket with a small throat, which may be made of pipe fittings. An engine which gives a perfectly smooth combustion line without such a pocket will give with the pocket explosive waves even when the ignition is quite late. In nearly every engine these waves will be produced when the ignition takes place before dead center, that is, during the time when the mass is agitated by compression waves from the piston.

These pressure waves are not to be confused with the occasional fluctuations of the indicator pencil due to the natural period of vibration of the piston and parallel motion of the indicator, although, according to my experience, the confusion is more likely to be the other way, the vibration of the indicator parts being more often the only explanation for the waves that are found.

PREIGNITION.

Whenever on compression a mixture ignites itself before dead center the phenomenon is called "preignition." Besides the many known easily avoidable causes, there are some that are difficult to understand. Any inward projecting part, such as a piece of asbestos gasket or rough edge of the casting, a bolt head, nut, piston compression plate, carbonized oil or possibly an ignitor, may get so overheated as to cause ignition. The compression causes a temperature increase, measured by the degree of the compression so that all parts of the gaseous mixture, except those directly in contact with cold walls, will suffer the same temperature rise, due to the compression. If there is near any particle of mixture another source of heat than the compression the temperature at that place will rise higher and may rise so much higher as to cause an ignition. It may be also that lack of homogeneity in the mixture will result in zones where the mixture has a lower temperature of ignition than at other places, for example, in places where lubricating oil is vaporizing or in the case of gasoline where the mixture is a little more rich in gasoline. This is another cause. In spite, however, of these traceable causes there seem to be some others, and these are mostly associated with the percentage of hydrogen in the gas.

At one time it was believed that the temperature of ignition of hydrogen was so low that the addition of hydrogen to a gas not previously containing it would lower the temperature of ignition of the mass, and design-

ers, including the writer, went so far as to announce figures for the reduction of compression for each per cent. of hydrogen present that was necessary to prevent preignitions.

Repeated experiments by the different engine builders and by engineers not associated with the building of engines point conclusively to the fact that preignition may occur when the percentage of hydrogen is low and may not occur when it is high and again may occur when it is high and may not when it is low for a given engine running on a given compression, but there seems to be substantial agreement on the statement that if the hydrogen were absent there would be no preignition at this compression.

A considerably detailed investigation carried on partly in the laboratory at Columbia and partly in the field seemed to indicate that it was not the percentage of hydrogen in the gas that fixed the tendency to preignite, but rather some ratio of the hydrogen to the other elements present. The remedies applied commonly for preignition troubles are twofold: first, a reduction in compression; second, an introduction of neutral elements, such as water to be vaporized into steam, steam itself or cooled and purified exhaust gases. This practice introduces greater variations in the mixtures than it is desirable to have, and is justified only in emergency, that the engine may continue to run.

Results of experiments made by Dr. K. G. Falk explain the apparent inconsistency between percentage of hydrogen in the gas and the conditions of preignition. It appears from his figures given for the temperature of ignition that in a producer gas containing hydrogen and CO with various neutrals mixed with oxygen the temperature of ignition does not depend on either the hydrogen necessarily nor the CO necessarily in the mixture, but on the relation that one of these bears to the oxygen present and which one can be determined only by computing the temperatures of ignition for the value and taking that value which is lower. One very significant fact in addition to the above is brought out by these results, and that is that the ignition temperatures and compressions formed are all very much higher than those used in engines. No ordinary engine uses compression anywhere near those determined for preignition.

It is evident, therefore, that as preignitions occur they are due not only to the compression, but also to other sources of heat. The interior parts must be hot enough in places to materially augment the temperatures produced by compression alone. As the final temperature, due to compression, bears a fixed relation to the initial temperature for any given compression that final temperature may be made higher not only by heat additions during the compression, but by a higher initial temperature. High temperature burnt gases retained in the cylinder are, therefore, detrimental and scavenging would be an assistance, but it is doubtful if initial temperatures are high enough in actual engines to account for the preignitions which occur, judged in the light of these ignition temperatures measured, and it is, therefore, extremely likely that all heat effects, not necessarily for the entire cylinder, but for some part, are the real causes and in addition the occasional presence of a certain sensitive proportion between oxygen and either CO or hydrogen.

The solution of the problem of controlling preignition resolves itself into three parts: (a) Maintenance of proportion of the elements of the mixture to those having the higher temperature of ignition, provided this mixture will still contain enough oxygen to burn all the fuel present; (b) Care in securing as low an initial temperature of the mixture as possible by maintaining inlet passages cool and purging the cylinder as completely as possible of burnt gases. This also involves the maintenance of early ignition to reduce final release temperatures; (c) Care in designing the machine so that interior parts shall be as well cooled and as uniformly cooled as possible. A well cooled cylinder with one spot, such as a nut, poorly cooled may just as well be poorly cooled throughout.

The prevention of explosive waves entirely in engine cylinders seems to be impossible. They can be avoided to a large extent and practically eliminated by giving attention to the form of the combustion chamber and to the method of igniting so as to avoid the generation of successive waves that might superimpose, but precisely how this is to be done cannot be said at this time, and more research will be required before a solution is possible. It may appear in the light of complete information that no solution will ever be possible.

The maintenance of uniform cylinder mixtures involving, as it does, first, the correct and positive proportioning of air to gas, and later, the uniform mixing of this primary mixture with the burnt cylinder gases in always constant quantities, is a thing which is abso-

lutely impossible with the present type of engine. Careful design can do much, but I feel it cannot overcome, so long as present types are adhered to, the numerous difficulties here presented.

These three phases of the general subject of our lack of control of internal combustion in exploding engines, namely, the maintenance of mixture proportions, the elimination of explosive waves and preignitions are all worthy of much study and are all difficult problems in themselves. It is hoped that in this presentation of the conditions to be met that designers and builders of these engines, as well as the users, may be led to continue the investigations and to announce their results.

THE FIELD OF THE MECHANICAL ENGINEER*

By F. R. HUTTON, E.M., Sc.D.

The convening of the American Society of Mechanical Engineers for its annual meeting in the splendid building devoted to the needs and uses of such a society makes it appear fitting to consider, in the opening address, the field of the Mechanfcal Engineer. What is the mechanical engineer at the opening of the twentieth century?

In seeking a defensible definition of the mechanical engineer in these days, which are those of specialization on the one hand and of broadening scope upon the other, there are several courses open. The first and obvious one is to rest upon authority and inheritance and to follow recorded standards which have some vogue or acceptance. A second is to gain definiteness of thought by differentiating the mechanical engineer from other specialists by noting what lines of professional activity are not his. A third method is to scrutinize the list of membership in the society and so divide the members into groups as to generalize therefrom as to what the man is doing who is or claims to be a mechanical engineer.

In turning to the historical definition, or that which has its authority from long usage, the stately language of Tredgold of England always claims first place as of right. At a meeting of the Council of the Institution of Civil Engineers of Great Britain on December 29, 1827, Mr. Tredgold, Honorary Member of the Institution, was requested by resolution, to "give a description of what a Civil Engineer is," in order that this description might be embodied in the petition for a charter for such a body. Mr. Tredgold's historic definition is:

"Civil Engineering is the art of directing the great sources of power in Nature for the use and convenience of man." He amplifies this by adding that it is a practical application of the most important principles of natural law, and has among its objects that of improving the means of production and of traffic for external and internal trade, such applications being directed to the construction and management of roads, bridges, railroads, aqueducts, canals, river navigation, docks and store houses, ports, harbors, breakwaters, moles and lighthouses. He includes also the protection of property from injury by natural forces, as in the defense of tracts of land from encroachments by sea or rivers; the direction of streams and rivers for use either as powers to work machines or as supplies for towns or for irrigation, as well as the removal of noxious accumulations as by drainage. He touches also upon navigation by artificial power for the purposes of commerce, and adds that the scope of utility of Engineering will be increased with every discovery in natural law and physics, and its resources with every invention in mechanical and chemical art. The Charter of the Institution repeats the Tredgold wording, and describes the profession of the civil engineer as "the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade as applied in the construction of roads and bridges, aqueducts, canals, river navigation and docks for internal intercourse and exchange and in the construction and adaptation of machinery and in the drainage of cities and towns."

In comment upon this definition it may be observed:

*From the Presidential Address at the New York Meeting (December, 1907) of The American Society of Mechanical Engineers.

It should receive the respectful homage which is due to a great achievement. Its breadth and comprehensiveness show us how great was the man who created it, and so early in our industrial history. By suitably extending the meaning of its terms and by reading into them the fuller significances of the later years, the definition is still defensible for what it can be made to cover. We have not outgrown it yet, by any means.

It should be regarded as a definition of Engineering in its broad and comprehensive sense, and should not be used to apply only to that specialized department of the profession to which in America the term civil engineering is applied in education and in popular use. What Mr. Tredgold meant was the profession of the civilian practitioner of engineering, as distinguished from the military engineer, the latter being concerned with the special problems of the fortress and the work of the army. The civilian and the military engineer have much the same problems in any case, and the military engineer in the field of ordnance becomes perforce a mechanical engineer of high order, but the purpose of the Tredgold definition was to form the basis of a charter for an organization of civilians as differentiated from employees of the British Government in their own engineering field; and the qualifying word applied to the engineer should be so understood in the light of its purpose.

In the third place, it should be noted that this definition of engineering as practiced by the civilian was given in the infancy or at the birth of the modern industrial epoch in which we are now living. This constitutes an element of the admiration we must feel for the greatness of its creator, that under these conditions he should have seen so far, but the fact is also responsible for the limitations which are suggested by it and which must be removed in the light of our present clearer vision. The year 1827 was two years in advance of the competition at Rainhill, where Stephenson won fame for the solution of the motive power problem of the railway: the first power driven steamboats on the Thames had been struggling against the tides only since 1813, and Dr. Dionysius Lardner had convinced all conservatives that the consumption of fuel as the standard then existed would preclude all successful working of long distance marine service such as across the Atlantic Ocean or around the Cape. The machine tool was still a small thing, whose tools were held by hand to the work to be done. Engineers were highly pleased when the fit of the engine-piston in the bore of the cylinder was so close that "at no point in its circumference or traverse could you drop a shilling through the space between the two." The mining of England while important, relatively, was yet limited for lack of shaft-machinery and was largely or entirely carried on by mine-bosses of experience. Faraday had yet four years to labor before he made his historic discovery of the electric current induced by motion before the pole of the magnet. The metallurgist and chemical engineer could only come into being when the needs of a community, built upon industrial production with cheap power at its base, should have called for him. What did exist were mills driven by water-power: the iron works built upon the puddling and rolling processes originated by Henry Cort, and the achievements of Boulton and Watt in respect to stationary steam engines. Nasmyth with the steam hammer and the large machine tool were still in the future; but most of all and most significant of all from the present point of view, the idea of manufacturing or production upon a large scale, in factories or shops where great groups of productive machinery were gathered together to be served by a common source of mechanical power had not yet been born. The industrial community or civilization made possible and present by the combined achievement of the physicist, the mechanical engineer and the electrical engineer, in whose powerhouse and from it are liberated, generated and transmitted the vast volumes now in use of industrial energy is truly dependent upon the powers of nature controlled and directed by engineers. The implication is, however, that these furies of nature are in existence and active and are awaiting control and direction. The definition is silent upon that group of engineers concerned with the liberation, the generation and the transmission of forces which are potential and are not realized in nature until in accordance with the natural law some engineer has caused them to appear.

The inclusion of the powers of nature within the scope of the elements of the profession of engineering carries with it the utilizing of the resisting forces created in the materials of engineering when such powers are exerted to deform them. Engineering, therefore, correctly covers the creation of structures to resist the dynamic action of forces, meeting by the principles of statics the impact or action of impressed energy. The definition might properly be extended, therefore, to cover both the adap-

tation of the physical properties of the materials of nature or manufacture to the withstanding of stress, and the direction and control of forces.

Finally, he who commits himself to the splendid Tredgold definition must take its alleged defect with its excellency. It is that it includes as engineers not alone those who create and install apparatus to control and use the powers of nature, but those also who direct and control the machines or apparatus when created and installed. This will include those whom I will call "co-ordinators of design," who take the boilers, engines, dynamos, condensing apparatus, piping and pumps which are on the market, and combine these into a consistent whole. They have not designed any of the units themselves, or created a new machine, but they have created a power-house, and are utilizing the powers of nature for the use and convenience of man. Somewhat under the same category is he who receives the finished power-house with all its units from the foregoing type of engineer and his allies, the contractors who have done the construction work, and is then and thereafter entrusted with its up-keep, repair and continuous operation. Such a man also directs and controls the powers of nature, albeit on a less exalted plane than the creator or designer or the co-ordinator. There are those who would make the co-ordinator appear as a mere purchasing agent, and the operator as a mere craftsman, and neither an engineer. I cannot agree with them, believing that their function calls for skill and acquirement of a high order. The historic definition unquestionably provides for them.

If the writer may modestly put forward a suggestion for a revision of the historic definition, he would word it: "The Engineer is he who by science and by art so adapts and applies the physical properties of matter and so controls and directs the forces which act through them as to serve the use and convenience of man, and to advance his economic and material welfare."

It may be of interest to add that the accepted dictionaries of the day, the Century and Standard, define the engineer as one versed or skilled in the principles and practice of any department or branch of engineering, deriving the word from older forms which means he who makes or uses an engine. Engineering is further explained as the science and art of making, building or using machines and engines; or of designing and constructing public works or, the like, requiring special knowledge of materials, machinery and the laws and principles of mechanics. Both give as a secondary meaning one who runs or manages an engine. Both the French and the Germans avoid this latter double use of the word by calling the practitioner of this sort of engineering a "machiniste" or a "maschinist." The French also have the word "mechanicien." The dictionary phrases are a little hard on the mining engineer, for example, who is scarcely visible in the description.

This leads up naturally to the differentiation of the mechanical engineer from those versed and skilled in other branches.

In making the following classification it is obvious that unanimity cannot be secured from all as respects the number of branches to be recognized. With this apology and for the purpose in hand there are at least thirteen:

The mining engineer, as well as his close ally, the metallurgical engineer, is concerned with the discovery and the winning and extraction from the earth of its buried treasures of oil, fuel and rock. He touches the geologist and mineralogist on one side of his functions and the chemist upon the other. Midway he allies himself to the mechanical engineer for the power to overcome his resistances and to the electrical engineer for its convenient transmission to the working-point. If he concentrates his ore after winning it from the earth he calls again for his machinery upon the mechanical engineer. His profession passes at one limit into the craft of the quarry man; and the other, he calls on the art of the civil engineer for his tunnels and for his shafts; or the tunneling and shaft work of the civil engineer is done for him by the miner. The metallurgical engineer, who transforms the crude ore into marketable metal or into the merchant form or structural shape, is allied to the chemist upon the one side for his processes and to the mechanical engineer upon the other for his machinery. The electrical engineer is more and more furnishing him the energy for conversion by heat through electrical channels, the mechanical engineer furnishing the latter his power. The mining engineer may be both miner and metallurgist. The iron and steel metallurgist is usually a mechanical engineer.

The electrical engineer is primarily entrusted with the transformation of mechanical or chemical energy into electric form, and its transmission in that form to the point of use, where it will be again converted into some

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other shape. The electrical engineer has made his own the question of generating such electric energy for the solution of the problems of lighting, transportation of passengers by railway, and communication by telegraph and telephone. He touches the physicist in the realm outside his applications of science, and has the mechanical or hydraulic engineer next to him to supply mechanical energy to his generator, and the mechanical engineer beyond him, where his energy drives the tool or operates the pump or the elevator. Where his energy is made to appear as high heat he serves the metallurgist, the chemical engineer; where it appears as low heat or as light he serves the individual members of the community directly, as he does in the problem of communicating speech. His field is very definite.

The naval engineer and marine architect is a specialized mechanical and structural engineer. His hull is a truss, unsymmetrically loaded and variably supported; his motive power a definite yet widely diversified problem. He covers, in addition, a wide range of special problems when his vessel is also a club house or hotel, on the one hand, or a powerful fighting machine upon the other.

The military engineer must cover both the defensive and the offensive department of his avocation. On the one side he is a structural engineer, and the problems of effective transportation enter his field, which he therefore shares with what is usually called the civil engineer. On the side of attack, the problems of ordnance, both for its construction and for its operation, take him into the field of the mechanical engineer and electrical engineer; and his problems touch those of the physicist and the chemist and the mathematician on the research and theoretical side. In fact, the problems of the military engineer are probably those in which the solutions offered by pure theory can be most directly utilized of any presented to the engineers, inasmuch as questions of cost and of financing are usually secondary for him. If the result is worth attaining at all, the national governments will always be among the most lavish spenders.

The chemical engineer is a new applicant at the door of professional recognition in certain quarters. He is the engineer in charge of production or manufacture where the process or the product, or both, are chiefly or entirely dependent upon the theories and practice of chemistry. He shares his field with the metallurgical engineer as respects the manufacture of metals; he is a mechanical engineer as soon as the plant becomes large enough to warrant the application of power and machinery to the mechanical handling of his product. Gas plants, sugar and oil refineries and the straight chemical manufacturing corporations call for such a man, whatever his designation. It would appear, however, that the normal tendency of growth and development in this field will be toward the utilization of two types of man. The one will be the chemist and the scientist; the other will be the mechanical engineer and executive. It may easily happen that in the days of small things the two sets of duties may devolve upon one man; later on it will be found that the best qualifications for both duties will not be found in one individual, and the volume of duty becomes too great for one man to be effective in both. When separated, the cleavage will be along the above lines.

The sanitary engineer is a specialist in hydraulic engineering in the applications of water supply and drainage as means to secure the wellbeing of the community as respects its public health. His field expands from that of the wise precautions respecting the piping of the individual house, where he touches the craftsmanship of the plumber, up to the broadest problems of sewage disposal and utilization, and the healthful supply of potable water for cities, free from bacterial or inorganic pollution at its source or in transit. His co-workers are the bacteriologist and the physician. It would seem more serviceable, however, for the purpose in hand to group such men with what are hereafter to be called the civil engineers.

The heating and ventilating engineers, making a specialty of the sanitary requirements of enclosed houses, as respects their fresh and tempered air supply, are really sanitary engineers, having, however, an outlook and a relation to mechanical engineering in the appliances of their function rather than toward civil engineering.

The refrigerating engineer is concerned with the transformation of mechanical or heat energy, so as to lower the amount of such intrinsic energy in any material or space. He is most unassailably a mechanical engineer.

The hydraulic engineer is of two groups. The one type concerned with the problems of the river or canal for navigation or for power with the dam and its accompanying details of waterways and controlling gate houses and sluices; and with the gravity storage and dis-

tribution by mains of the city water supply has plainly his outlook toward civil engineering. The other type, concerned with the water motor and its attached machinery for its operation; with the mechanical handling of water for city use or for power in industry, the designer of pumps and hydraulic utilization machinery has his outlook equally definite upon the field of the mechanical engineer. The future is likely to see this differentiation emphasized, the one class calling himself a civil and hydraulic engineer, and the other class a mechanical and hydraulic engineer.

The gas engineer has two sets of problems: The one is the intra-mural manufacture and storage of his product, where his functions are those of the chemical manufacturer, and he should be both chemical and mechanical engineer; the other is the distribution problem, for whose solution is required the skill and knowledge of a type which is unnamed, but which, logically, in parallel with the hydraulic engineer above, should be called the pneumatic (or gas) engineer. Industry has never stopped to be logical, however, and the pneumatic engineer should be a name to suppress. The future will doubtless widen the scope of the gas engineer to cover the plants which make and use fuel gas for power and heating in units not so large as those on the municipal scale now in evidence for lighting mainly. Such creators and engineers for heat and power will plainly belong in the mechanical field.

There is no recognized group of engineers of transportation, or transportation engineers. Such a group obviously exists, however, whether or not the name is attached to an organization inclusive of all, or is in general use. Such are the engineers of motive power on the steam railways, with the master mechanics and the signal engineers and the operative class on locomotives; such are the street railway engineers, the car builders, the maintenance-of-way engineers, the bridge engineers, the engineers of floating equipment. From the bottom of the rail upwards these have their outlook on mechanical or electrical engineering; from the bottom of the rail downward, upon civil engineering.

The foregoing grouping does not claim to be exhaustive nor inclusive of all subdivisions of engineers, even so far as it has gone. The current activities of the engineering building reveal bodies of municipal engineers, of illuminating engineers, of engineers concerned in fire protection, and many others. But the purpose has been to clear the way for the separation of the two most closely allied in function and service, the civil and the mechanical engineer. The civil engineer is confessedly differentiated from the electrical and from the mining engineer; he has been more and more utilizing the achievements of the mechanical engineer, or the latter has been invading the former field of the civil engineer.

It is plain that to the civil engineer belong as of right all problems relating to the canal, the lock, the river, the harbor, the dock, the sea-wall, the breakwater, the highway, the aqueduct, the bridge, the viaduct, the retaining wall, the permanent way of the railway below the foot of the rail. He also has nearly the whole of the municipal problem in streets, sewage, distribution of water, the location of railways, with geodetic and other surveying are his. He has the foundation of structures, in any event, but may have to share the roof and the skeleton steel frame with other specializations. Tunneling is usually done by civil engineers, although it was originally a mining engineer's prerogative.

To the mechanical engineer, on the other hand, belong, as undoubtedly and as of right, the problems of the generation of power in power-houses and power plants, and its transmission to the operative-point, unless this latter is done by electric means. It is a fair question, however, when the electrical engineer simply transmits energy generated by the mechanical engineer and utilized in industry by the latter after transmission, whether the electrical engineer, as an engineer of transmission, is not for the time a mechanical engineer. If the transmission were by compressed air on a sufficient scale, calling for a specialist in that field, would such a man be called a compressed-air engineer?

It is also plain that to the mechanical engineer belong all design, creation and manufacture of tools and machinery. This makes him, therefore, the natural administrator or executive of the production processes involving the use of machinery in factories and mills, and it is here that he finds his broadest scope and widest opportunity, as will be further demonstrated hereafter. As creator of machinery he will be a draftsman or designer of a producing plant; as operator of the plant, considered as a tool for production, he will be a general manager or superintendent, or will perform these functions as owner or as president, vice-president, agent, secretary or treasurer. As a producer of power, the railway will

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make the mechanical engineer their superintendent of motive power; and the rail and joint become also responsibilities of his; as administrator of men and machinery, he becomes master mechanic of the railway, and more and more such engineers are chosen to be general superintendents. The automobile or motor vehicle engineer is of course a mechanical engineer. From his knowledge and special training he becomes the inspector and tester for all departments of mechanical production.

But this relation of engineer of production, borne by the mechanical engineer, is at the bottom of very notable developments of progress. As the scale of production increases with the aggregation of capital invested, the permanence of the business becomes inseparately bound up with the satisfactory quality of its output. Hence there grows a system of business in which the reputation of the producer becomes a factor, compelling him to satisfy the buyer as respects the engineering excellence of his purchase; and it becomes possible for the contract between the two to be based upon the specifications created by the producer or seller, and not by the engineer or the buyer. This makes for cheapness and promptness of production and delivery, since standard articles become possible and frequent. It is a system lying largely at the base of the American success in competition in foreign markets, as it differentiates our practice from that of England, for example. It points to a narrowing of the scope of the office of consulting practitioner, as compared with the widening scope of the manufacturing engineer. It marks a broad differentiation between the civil and the mechanical engineer, in that the former never or very rarely attaches himself to a producing interest. He serves a municipality, a corporation or an individual always as a representative of their interests as a buyer or user. It is his function to see that specifications, unfriendly in intent to the interests of the seller, are carried out by the latter. The engineer of production is called on to originate his specifications and to enforce them in production, in order that the guarantee of quality and of economy in use may both be satisfactory to such user. The entire point of view of the two types is radically diverse.

This achievement of the manufacturing or production engineer gives significance to the work of the considerable group of mechanical engineers, who have been earlier designated as "co-ordinators of design." These are they who take the satisfactory designs or creations of the producing engineer and combine such elements into a unit for some industrial purpose. It would be foolish and unwise for such men to pass by existing standards upon the market and create special designs of their own. These latter would not only be more costly to pay for, but their delivery would be slower, and problems of repair and replacement be many times more difficult, costly and delaying. Their creative function as engineers, however, is different from that of the producing engineer proper; yet to succeed demands the same faculty of critical selection and of adaptation of means to ends, upon a basis of sound science, which distinguishes the other group. To them belong those engineers of operation and development of existing plants, who rarely create, but who skilfully select and adopt and combine.

This economic condition also has given rise to a group of engineers properly mechanical, who are directly and productively related to the producing corporations as their representatives in their selling organization over a large territory. It is unfortunate that these men of professional standing and of engineering qualification should be so often called "sales managers." It is their duty to act exactly as the co-ordinator of design does in his office, and secure for the intending purchaser an engineering solution for his needs which shall be satisfactory to him. His value to the producing corporation is inevitably measured by the number of contracts which he brings them: his value to his clients is measured by the engineering value of the specifications upon which such contract is based. The mere salesman could not perform the duty of the case, unless the buyer were protected by a consulting engineer. It is economically to be preferred as above, to have the specification emanate from the seller.

And finally, the group of engineers of production must include the industrial engineers who are organizers of men or departments or works as tools of production. These men are not creatures of visible machines embodied in steel or iron, which perform material functions before our eyes. Yet are they creators of power and directors of forces under the fundamental definition. They may do this as independent consulting engineers from an office relation; or they may be continuously employed for this purpose by one producing concern. In either case their successful achievement is the same in principle

and in result as that of him who devises a new automatic machine by which output is increased and cost of production cut down.

The final criterion or touch-stone for all these claims for the scope and function of the mechanical engineer must be the answer and attitude of the profession itself. The American Society of Mechanical Engineers exists to promote the Arts and Sciences connected with Engineering and Mechanical Construction. The member must be competent to take responsible charge of work in his branch of engineering as designer or constructor, or he must have served as a teacher of engineering. The associate must be competent to take charge of engineering work or to cooperate with engineers. This brings in the journalist, the patent lawyer, the business man, the contractor. The junior must be either an engineering school graduate, or have had such experience as will enable him to fill a responsible subordinate position in engineering work. Candidates must be proposed by members of the Society, supposedly familiar with its functions and standards, and such proposers are called on to answer searching questions by the scrutinizing Membership Committee of five. The Committee on Membership reports recommendations of qualified persons to the Council of the Society, who again scrutinize the list, and it is finally submitted to the entire voting membership by letter ballot, with privilege of rejection by a limited number of adverse votes on any name. Hence it may be assumed that the membership contains only those whom the administration of the Society and its active membership regard as suitable members of a Society of Mechanical Engineers.

Who are these members, and what are they doing? A convenient classification, according to their occupations, follows:

Group Name.	Numbers.		Percentage.	
The unclassified	306		10.3	
The army and navy	11		0.4	
and marine	18		0.6	
The hydraulic	12		0.4	
Patents	25		0.8	
Journalists	30		1.0	
Mining and metallurgy	31		1.0	
Engineering contractor	48		1.6	
Testing and inspecting	49		1.6	
Operating engineer	55		1.8	
Locomotive and railway	57		1.9	
Electrical engineer	65		2.2	
Professor and teacher	185		6.3	
Draftsman and designer	115		4.0	
Local manager	153		5.2	
Shop executive	338	1,572	11.8	53.6
The manufacturer	906		32.6	
Office practitioner	493		16.5	
Total	2,957		100.0	

There would seem therefore a good ground for defending a twentieth century Tredgold who should define or describe the mechanical engineer of his period: "The Mechanical Engineer is one who by science and by art so adapts and applies the physical properties of matter and so controls the forces which act through them as to serve the use and convenience of man and to advance his economic and material welfare. He does this mainly by storing and liberating motor energy through machines and apparatus which he designs and installs and operates for the purpose of fostering and developing the processes of industrial production which use and require such power upon a large scale."

FERRO-ALLOYS FOR FOUNDRY USE

By E. F. LAKE

CONDENSED FROM "AMERICAN MACHINIST"

To the layman, and for that matter to many machinists, cast iron is cast iron; but to those up in foundry practices and engineering there are probably as many qualities of cast iron as of any other metal, unless it be steel. Up to comparatively recent times iron and steel founding was carried out by rule of thumb, but scientific methods have now been introduced and all foundries of any size have laboratories in which the metals are analyzed and tested so that any desired quality of iron can be produced within certain limits.

Much of this improvement has been due to the perfection of the electric smelting furnace and its use in the production of rich ferro-alloys at a comparatively moderate price. Among those which are important to foundrymen might be mentioned spiegel, ferro-manganese, silicon-spiegel, ferro-silicon, ferro-chrome, ferro-phosphorus, ferro-aluminum, ferro-titan-

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ium, ferro-vanadium and mixed alloys of the above elements.

These elements add different properties to cast iron, such as hardness and softness, while refining the grain, removing blow-holes and microscopic cracks, increasing the strength, lowering the sulphur and phosphorus contents, etc.

Ferro-manganese and spiegel are used more than any of the other elements in making cast iron, and differ only in that the former contains a high and the spiegel a low percentage of manganese. These are used both to harden and soften cast iron, and the results are obtained by a high or low percentage of manganese, which, however, varies with the amount of carbon as well as the sulphur in the iron; its work is largely governed by these. As an example of its hardening effect, one pound of ferro-manganese is put in the bottom of a ladle into which is tapped 300 lbs. of cupola iron to produce the chill in car wheels.

Silicon-spiegel is closely allied to the foregoing, as it contains a considerable amount of manganese. The silicon increases the solubility of gases in the metal when solidifying, thus preventing honeycombing, and also has a softening effect which is further enhanced by the manganese, as this reduces the sulphur. Both are deoxidizers of considerable power.

Ferro-silicon tends to convert the carbon contents to a graphitic condition and so produce a soft casting. Some tests have shown that when added in the ladle a gain in transverse strength and deflection of 24 and 30% respectively was made.

Ferro-chrome is a hardener and is used where hard wearing properties are desired, as in cast-iron piston rings.

Ferro-phosphorus makes iron very fluid when molten and causes it to make a fine impression in the sand and is therefore used to advantage in fine thin ornamental or artistic work where strength is not considered, as a high percentage of phosphorus makes iron very brittle.

Ferro-aluminum is used as a deoxidizer and thereby refines the grain; but very little of it should remain in the metal, as it is liable to remain suspended and thus cause a loss in strength by the lack of continuity of the metal.

Ferro-titanium acts as a deoxidizer and combines with both oxygen and nitrogen, therefore aids in removing these gases and thereby produces sound castings. It increases the transverse strength and the hardness of the chill of cast iron.

Ferro-vanadium refines the grain and reduces the porosity of cast iron as well as increasing the breaking strength. Thus it is useful for such castings as valves and explosive-engine cylinders.

AUTOMATIC BLOCK SIGNALS

By A. G. SHAVER

FROM "THE ROSE TECHNIC"

The large number of railway accidents occurring during the last year has interested the public to the extent that the block signal system, as a means of preventing the collisions between trains and wrecks due to broken rails and defective or misplaced switches, is being given greater consideration than ever before.

The several methods of block signaling, depending upon the manner in which the signals are controlled and operated, are divided into three classes:

1. The manual block system, in which the signals are manually operated by signalmen in accordance with information transmitted from one signalman to another.

2. The controlled manual block system, in which the signals are usually manually operated and so constructed and connected as to require the co-operation of the signalmen at both ends every time a train is admitted to the block.

3. The automatic block signal system, in which the signals are operated by any suitable power, as electricity or some compressed gas, and controlled electrically to indicate stop or proceed, depending upon the presence or absence of a train in the block or some

other condition affecting the safe movement of trains, as open switches or broken rails.

The manual block system appears to have been first used in this country in 1863 or 1864 on a line between Philadelphia, Pa., and Trenton, N. J., now a part of the Pennsylvania Railroad. This system is yet more largely used than any other, particularly on lines of light traffic and many single track railroads.

The controlled manual block system was introduced on the New York Central and Hudson River Railroad in 1882. It is now operated on more than 1,000 miles of railroad and its use is being extended.

Automatic block signals were invented and developed in America. Indeed, very few are yet in service in foreign countries. Records show that the first installation was made in 1871 near Boston on 16 miles of what is now a part of the Boston and Maine Railroad.

Block System.—A series of consecutive blocks.

Though the signal devices installed five or six years ago were considered very satisfactory and those in service at the present time are giving good results, yet there has been and is now a gradual evolution in the design of apparatus always tending toward simplification and increased efficiency at less cost.

The very earliest forms of automatic signals were of the clockwork and disk patterns, but, because of the greater visibility of the semaphore and because of its almost exclusive use for interlockings and the various manual signals, an automatic semaphore signal was soon developed and is now more largely used than any other.

All installations of automatic block signals have electro-magnetic controlling features and, with but few exceptions, electric track circuits.

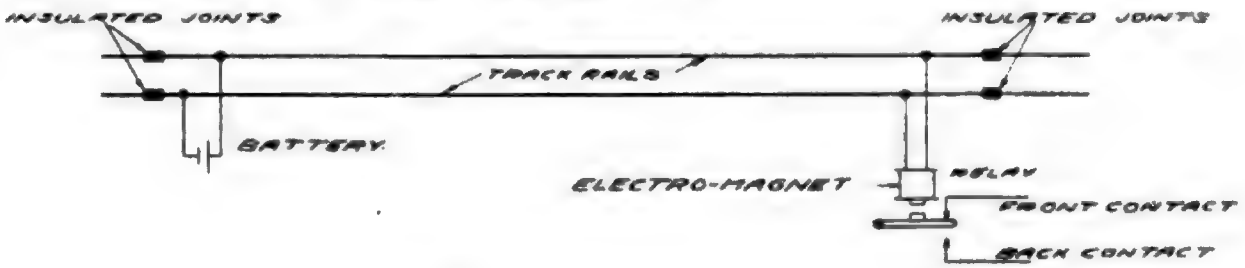

FIG 1.

Other installations followed at intervals, but it was not until 1879, when the track circuit was introduced and found practicable, that noticeable progress was made. Since that time there has been a steady growth in automatic block signaling till at the present time some 10,000 miles of railroad are so equipped.

The American Railway Association, of which nearly all the railroads in America are members, has explained some of the fundamental features and functions of block signaling in the following definitions:

Block.—A length of track of defined limits, the use of which by trains is controlled by block signals.

Block Signal.—A fixed signal controlling the use of a block.

Home Block Signal.—A fixed signal at the entrance of a block to control trains in entering and using the said block.

Distant Block Signal—A fixed signal used in connection with a home block signal to regulate the approach thereto.

Advance Block Signal.—A fixed signal used in connection with a home block signal to subdivide the block in advance.

It is only through the track circuit as a medium that absolute safety in block signaling may be attained.

The development of the art has been such that to-day an automatic block system signal system is considered very imperfect if a signal does not, by displaying its stop indication denote the presence of a train, a broken rail or an open switch in the block. The track circuit through which this is accomplished is very simple. A section of track is fixed upon for the circuit; an isolated joint is placed in each rail at each end of the section; all the ordinary rail joints coming within the section are bonded with two No. 8 B. W. G. E. B. B. galvanized iron wires; a battery is connected at one end of the section and the electro-magnet of a relay at the other end. Thus a complete circuit is established, the rails serving as conductors to connect the battery to the electro-magnet. Fig. 1 illustrates this.

Track-circuit sections may vary in length up to 6,000 and 7,000 ft., depending upon track and climatic conditions. These lengths are extreme and exceptional, however. Under ordinary track conditions with good drain-

age, untreated cross-ties and good gravel ballast free from rail contact, it is considered good practice to make them 2,500 to 3,000 ft. long.

The insulated joints are similar in many respects to ordinary rail joints with the exception that an insulating material, usually hard fiber, is applied in such a way that the two rails which are connected do not come into electrical contact.

The track battery ordinarily consists of two gravity cells connected in parallel, though in some installations a storage battery is being used with as good or better results.

The electrical resistance of the track is very low and with good bonding never more than 0.25 ohm per 1,000 ft. of track, which is about the maximum in cold weather with all the rail joints open.

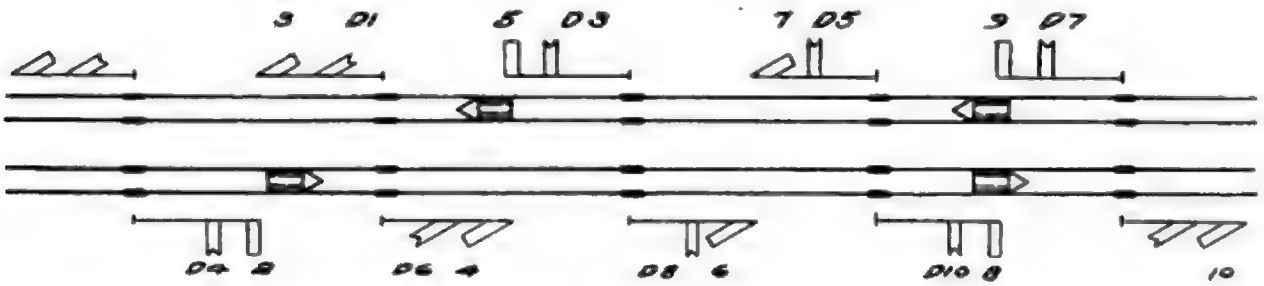

FIG. 2

The resistance of the track relay electro-magnet is usually 4 ohms, but in some cases, with well insulated track and short sections, a resistance of 9 ohms is used.

The track relay is equipped with contacts which, when the electro-magnet is energized or de-energized, make or break auxiliary circuits controlling the signals. Normally it is energized, but when a train enters the track circuit, the electrical resistance of the contact between the wheels and the rails is so small that the electro-magnet is practically shunted and the armature falls by gravity, thus operating the signal circuits.

High speeds and heavy trains require that that there should be a home and distant signal for every block. The length of block is dependent primarily upon the density of traffic. Where the blocks are 1½ miles or less in length, it is common practice to mount the home and distant signal arms on one post, the distant arm on any one post ordinarily operating as the distant signal for the home arm on the next post in advance. But where the blocks are longer than 1½ miles, to mount the distant and home arms on one post would bring the distant signal so far away from its home as to make its indication ineffective; therefore, in such cases the home and distant arms are mounted upon separate posts 2,000 to 4,000 ft. apart, the exact distance

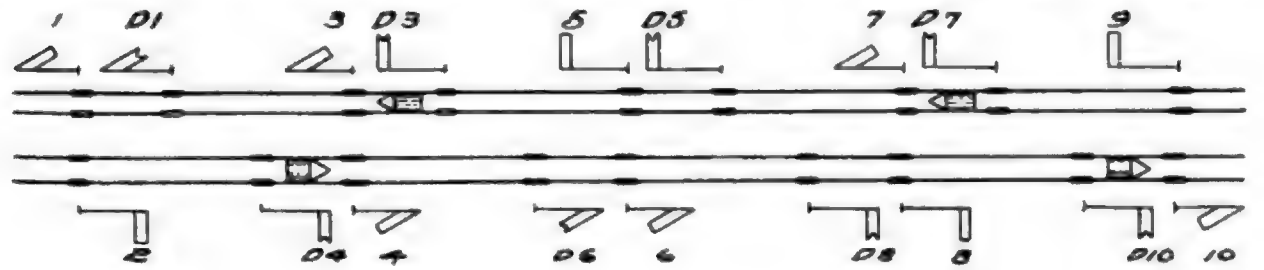

FIG. 3

being dependent upon the space required in which to stop the fastest train should the distant signal indicate caution and the home signal stop.

Many railroads now use as night signal indications, red for stop, yellow for caution and green for clear or proceed. When a home semaphore signal indicates stop, its arm is in a horizontal position and in addition at night a red light is displayed. When either a home or distant semaphore signal indicates clear, proceed, its arm is inclined downward, usually

60°, and in addition at night a green light is displayed.

Fig. 2 illustrates an arrangement of semaphore automatic block signals on double track where the home and distant arms are on the same post. Home signal 5 and distant signals D5 and D3 are indicating stop and caution respectively due to a train in the block of signal 5. The train in the block of signal 9 receives a caution signal D5, indicating that home signal 5 is at stop, and must therefore proceed prepared to stop at signal 5. If signals are equally spaced and this latter train always keeps the same distance behind the train ahead, it will run under caution signals all the way. It will be noted that the trains in blocks 8 and 2 are spaced with two blocks between them and each is running under both clear distant and home signals.

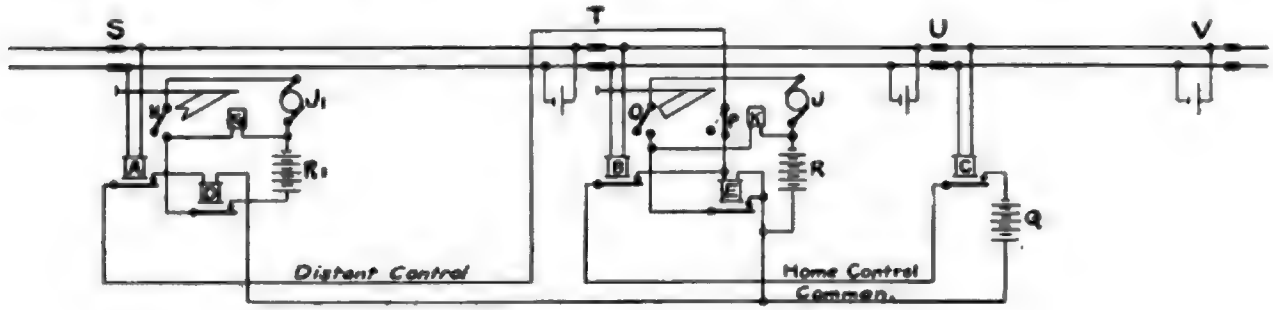

Figure 4

proceed, block clear, at all times excepting when the condition of the block is such that a stop signal should be given, as when there is a train or an open switch in the block.

A normal danger signal is one which indicates stop at all times excepting when the block is clear and a train, or some condition of the same effect of a train, is within a certain section or sections approaching the signal.

There is a great variety of circuits for the operation of either method, but it is the intention to show only one simple circuit for each here.

Fig. 4 is a typical normal clear wire circuit. Assume that a block TV, which is divided into two track circuit sections TU and UV, is protected by a home signal T and its distant signal S. A, B and C are track relays normally energized and operating through their front

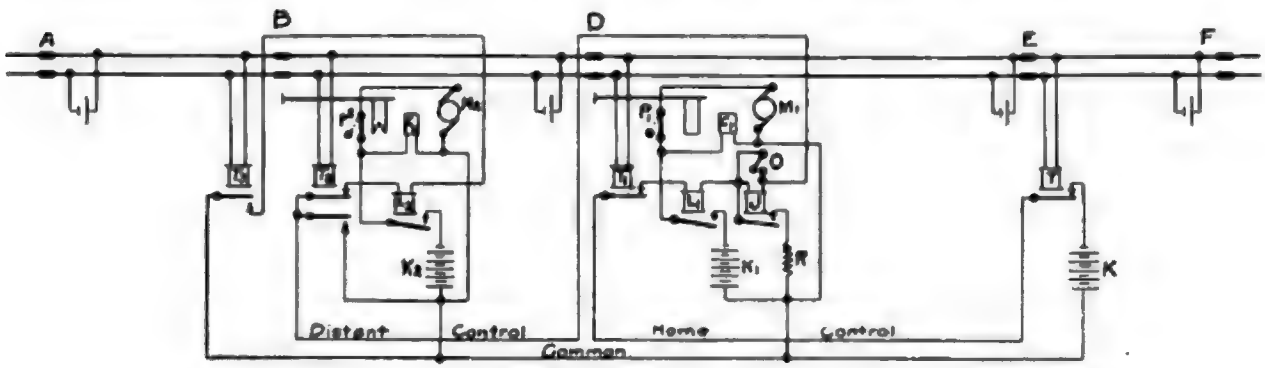

Figure 5

Fig. 3 illustrates an arrangement of semaphore automatic block signals on double track with the home and distant arms on separate posts. It is in effect the same as Fig 2 but with longer blocks.

There are two general methods of operating automatic block signals known as "normally clear" and "normally danger." Each has its advantages, each is largely used and each has its advocates among the principal signal companies.

A normal clear signal is one which indicates

contacts the control circuits for the signals. E is the control relay for the home signal, and its circuit, which is normally closed, is from common wire through battery Q, front contact of relay C, home control wire, front contact of relay B, electro-magnet of E and thence to common wire. Relay E controls the operation of the motor J and the clutch magnet K which holds the signal clear. Battery R operates the motor J and energizes the clutch K. Circuit breaker O serves to automatically open the motor circuit when the signal has cleared.

D is the control relay for the distant signal, and its circuit, which is also normally energized, is from common wire through battery Q, front contact of relay C, home control wire, front contact of relay B, circuit closer P, distant control wire, front contact of relay A, control relay D and thence to common wire. Circuit closer P is closed only when home signal T is clear. The motor and clutch circuit of the distant signal is exactly like that of the home signal. A train in either section TU or UV will de-energize the track relay and set

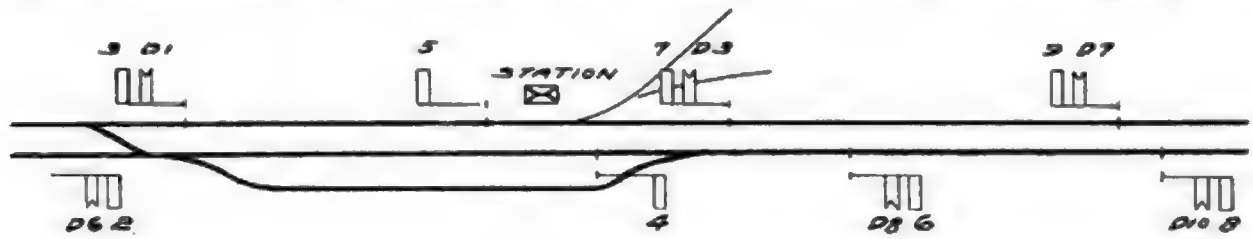

FIG. 6.

both signals. A train in section ST will de-energize track relay A and set distant signal S.

Fig. 5 is a typical normal danger wire circuit. The block DF, which is divided into two track sections DE and EF, is protected by a home signal D and its distant signal B. T, T1, T2 and T3 are track relays normally energized. Assume a train approaching B; when it gets into section AB, relay T3 is de-energized, closing its back contact. Thus a circuit is made from common wire through back contact of relay T3, control relay L2, front contact of relay T2, distant control wire, relay J, control relay L1, front contact of relay T1, home control wire, front contact of relay T and battery K to common wire again. Relays L1 and L2 are of much less resistance than relay J. When the circuit is made relay J gets enough current to pick up its armature but relays L1 and L2 do not. The lifting of armature J closes a circuit from common wire through resistance R, which is equal to that of relay L1, front contact of relay J, relay L1, front contact of relay T1, home control wire, front contact of relay T and battery K to common wire. Thus relay L1 is energized and through its front contact the clutch and motor circuit operating home signal D is made. As soon as home signal D clears, circuit closer O is operated to shut out the high resistance relay J; this then enables enough current to pass through the circuit from battery K to pick up the armature of control relay L2 and thus operate the clutch C2 and motor M2 to clear the distant signal. When the train passes into the section BD, relay T2 is de-energized opening its front contact to put the distant signal B to caution and closing its back contact to maintain the circuit ahead to hold home signal D clear. When the train passes into section DE, relay T1 is de-energized thus setting home signal D at stop.

The location of block signals on a line to be signaled is a matter of much importance. The traffic, grades, curves, topography of the country, location of switches, water-tanks, telegraph offices, stations, overhead structures, grade-crossings, tunnels, etc., all need careful consideration.

The signaling of a double-track railroad, because there is a track for traffic in each direction, is in many respects easier than signaling a single-track railroad.

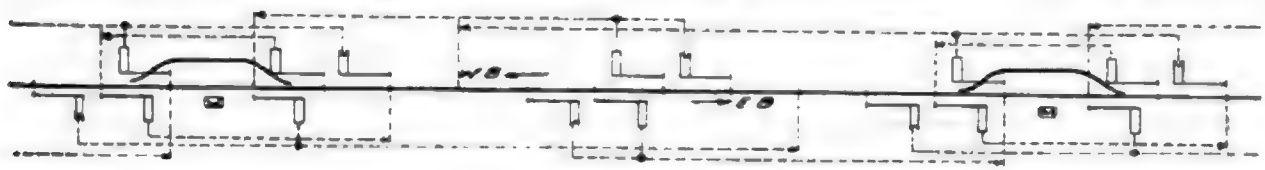

FIG. 7

Fig. 6 illustrates a scheme of automatic block signal location on double track. Signals 4 and 5 are what might be termed advance home signals because they serve to start a train which may have stopped at the station. Signals 7 and 2 are located so as to protect the rear end of trains which may be standing at the station as well as to protect against the possible wrong position of switches in their respective blocks. Each home signal governs only to the next home signal in advance. In this particular case signals D3 and D6 are distant signals for home signals 3 and 5 and 4

and 6 respectively. Since traffic is in one direction on each track, the signals furnish rear end protection only.

Fig. 7 illustrates a method of automatic block signaling single track. Since there must be both rear-end and head-on protection for trains, the signals must be located to meet this condition and their circuits so designed that the blocks overlap. The lines ending in arrows are intended to show the section of track over which each signal governs. With such an arrangement as shown in Fig. 7, it will be impossible for two trains to approach one another without each receiving a stop signal before they can meet, yet it will be possible for four trains following one another, or two trains headed toward each other, to be between two stations at the same time. The arrangement of signals and overlaps at passing sidings admits of two trains approaching each other very closely for the purpose of meeting and passing. As the overlaps are shown the direction rights should be for westbound trains.

GAS ENGINES AND INDICATORS

FROM "THE ENGINEER," LONDON

The Institution of Mechanical Engineers is to be congratulated on the first paper of the session and on the discussion, which extended over two evenings. At first sight the paper* by Professor Bertram Hopkinson might appear to deal only with certain academic points in connection with the inaccuracies of indicators and with errors of a secondary order involved in one of the methods of determining the indicated horse-power adopted by the Committee of the Institution of Civil Engineers on internal combustion engines. In reality, however, the matters dealt with are of practical importance, because, as pointed out by Mr. Dugald Clerk and Captain Sankey, the economy of gas engines is now so good that the margin left for improvement is quite small—so long as the present "constant volume" cycle is adhered to—and hence arises the practical necessity of inquiring closely into the accuracy of the instruments used, and into the methods adopted for determining both the thermodynamic and mechanical losses, so as to be able to assess accurately and to discriminate between the various losses. Take, for example, the thermodynamic losses. As is well known, the thermodynamic efficiency of the ideal constant volume cycle is given by the expression $1 - (1/r)^n$, where n is the compression ratio. If air is taken as the working substance for the ideal engine, and if the specific heat is assumed constant, we have $n = 1.4$, and the thermodynamic efficiency of the standard when $r = 6.37$ is 52.2%, as given in Professor Hopkinson's paper. Now, the highest thermodynamic efficiency of the engine tested by him is given as 37%, a figure, it may be observed, which is reached by many good modern gas engines, and the ratio between these two efficiencies, that is, the "relative efficiency" compared to the air standard cycle, is 71%, from which it would appear that there is a margin of 29% still available for improvement. But in the case of the actual gas in the engine the specific heat is not constant, and from the data derived from the experiments of Austin, Holborn, Dugald Clerk, and others, it can be shown that the thermodynamic efficiency can be obtained with sufficient accuracy by taking $n = 1.29$, so that the thermodynamic efficiency of the actual gas constant volume standard cycle is 41%. The ratio

$$\frac{\text{thermodynamic efficiency of actual engine}}{\text{thermodynamic efficiency of gas standard}}$$

is then 90%, showing that in reality there is only a ten per cent. margin for improvement. In this connection we would point out that the Institution of Civil Engineers adopted, on the recommendation of their Committee on the Thermal Efficiency of Steam Engines, the term "Efficiency Ratio" for the above ratio, and we think this term should also be adopted for gas engines when the comparison is made with the actual ideal gas cycle, employing the term "Relative Efficiency" when the comparison is made with the air standard cycle, as was recommended by Captain Sankey in the discussion on Mr. Dugald Clerk's paper read last winter before the Institution of Civil Engineers.

If we suppose that there is an inaccuracy of ± 5% in the determination of the I.HP., the efficiency ration of 90% would become approximately 85% and 95%, according as to whether the error is positive or negative. A greater

*On the Indicated Power and Mechanical Efficiency of the Gas Engine.

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accuracy than ± 5% in the determination of the I.HP. is therefore imperative, if we desire to obtain any true idea of the margin of improvement remaining. Now it was abundantly clear from the discussion that with the ordinary pencil indicator errors of ± 5% are to be expected, but that with the mirror indicator an accuracy of ± 2% can easily be obtained. Hence, when the object of indicating is to determine the thermodynamic efficiency and the efficiency ratio, the mirror indicator should be used. Such tests will doubtless either be carried out in laboratories, or else at the maker's works, and the great delicacy of the mirror indicator is then of no disadvantage. For tests on the user's premises, and for other important uses of the indicator which we need not specify, the pencil indicator will, we feel sure, hold its own. An objection was raised, on the score of accuracy, to the thickness of the line usually obtained with the mirror indicator. Doubts on this point were entirely dispelled by the beautiful diagrams exhibited by Professor Hopkinson and by Mr. Dugald Clerk. It was difficult to realize that the diagram thrown on the screen by the former was the superposition of 100 indicator cards, so fine was the line. Evidently even the smallest transient change would be noticeable, and hence the value of this form of indicator when examining visually by means of a telescope, as, for instance, in the case of research work on the effect of water injection, as suggested by Professor Hele-Shaw.

An important question was raised by the paper and the discussion, viz., the definition of the I.HP. of a gas engine. It appears to be customary to deduct the negative loop, due to the pumping stroke of the Otto cycle, from the positive loop due to the combustion of the gas. From the point of view from which we are at present considering the matter, this procedure is obviously incorrect, and apparently it has only the questionable commercial advantage of making the brake efficiency of the engine appear larger than it really is. Professor Hopkinson showed that the area of the negative loop in the engine he tested was, at full load 3.4% of the positive loop, so that if deducted the I.HP. would be 3.4% smaller than given, and the efficiency ratio of 90% already referred to would be increased to 93%. In fact, if the valves were made small enough so as to get a large negative loop, the efficiency ratio might be made 100% or more. We therefore fully agree with Professor Hopkinson's recommendation that the I.HP. should be obtained from the positive loop without deducting the negative loop, and we suggest that it be accepted for standard practice.

Professor Hopkinson dwelt at some length on one of the methods adopted by the Committee of the Institution of Civil Engineers on Internal Combustion Engines for determining the I.HP. at full load from the brake horse power. The assumption made by the Committe was that the loss is constant at all loads; hence, if the I.HP. at no load is determined by the indicator, this I.HP. can be taken as equal to the difference between the I.HP. and the B.HP. at full load, and since the error of the indicator affects only the I.HP. at no load, a ± 5% error of the indicator produces only—if the brake efficiency is 86%—an error of $5 \times (100 - 86) \div 100$, or say ± 1.5% in the final result. But the loss at no load is largely due to the negative loop, and, as pointed out by Professor Hopkinson, the majority of these loops are larger at no load than at full load, because the loop, when only air and no gas is drawn in, is larger than when both gas and air are drawn in; an overestimate of the loss is thus made, and a correction should be applied. The amount of the correction will however, depend on the engine under test, for in some the negative loop, and in particular the proportion between the gas loop and the air loop, is larger than in others. In the case of the engines tested by the Committee of the Institution of Civil Engineers, it would appear that the negative loops were smaller than in the engine tested by Professor Hopkinson, so that in the case of the Committee's trials the error caused by not taking into account the air loop is probably small, and would not materially affect the brake efficiency obtained. On the other hand, although Professor Hopkinson's tests show clearly that the pure mechanical friction is constant, and does not increase with the load, and that the consensus of opinion points in the same direction, we think it is probable that there may be a slight increase in the friction loss as the load becomes greater, and this would tend to correct the error introduced by not taking the air loops into account. This method of determining the I.HP. of gas engines, when pencil indicators are used, appears to us of such considerable value, inasmuch as it practically eliminates the error of the indicator, that we think it is much to be desired that it be further investigated, in order to put at rest the doubtful questions above referred to.

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THE SPECIFIC HEAT OF SUPERHEATED STEAM

During the past three years extensive series of experiments have been carried on at Sibley College, Cornell University, for the purpose of determining the specific heat of superheated steam. The results of these experiments were presented in a paper by Professor Carl C. Thomas, read before the American Society of Mechanical Engineers at its annual meeting in New York, during the first week of December.

The method employed by Prof. Thomas and his assistants was briefly as follows:

All conditions having been arranged so that they could be controlled, thus providing for practically absolute steadiness of steam pressure, voltage and steam supply, steam was started through a calorimeter and the whole system was allowed to run for several hours before taking readings. When finally steady conditions had been obtained, steam of a certain quality was entering the calorimeter. Electrical energy was introduced sufficient to dry this steam as indicated by the thermo-junction in the calorimeter. Any change in quality was at once indicated by temperature change. Standard conditions having been obtained—that is, a given quantity of steam passing through the calorimeter per unit of time and receiving just enough electrical energy to dry it and thus bring it up to the "standard" or dry steam condition; then enough more electrical energy was added to raise the temperature of the steam through a given range, either 20, 40, 60, 80, 100 or 150 degs. C. corresponding to 36, 72, 108, 144, 180 and 270 degs. F. respectively. The energy required to produce this rise of temperature having been noted, the initial standard (dry and saturated) conditions were gone back to by dropping out the energy introduced to give the range of temperature. This formed a check on the constancy of the standard condition. From these data specific heats including radiation from the instrument were calculated for the various pressures and temperature ranges employed.

It was found from these experiments, the results of which were presented in graphical form, that the specific heat of superheated steam varies with both the pressure and the temperature. It increases when the pressure of the steam increases and diminishes with an increase in the temperature. The specific heat increases and decreases more rapidly when near the saturation point, with increase of pressure and temperature, respectively, than is the case in conditions more remote from the saturation point. These conclusions apply over the whole range covered in the investigation, which included pressures from 7 lbs. absolute to 500 lbs. absolute per sq. in. and up to 270° F. superheat, for all pressures employed.

The specific heat of superheated steam is of interest to engineers because upon it depend the answers to the two following questions:

How much does it cost, with given efficiency of steam-heating apparatus, to produce superheated steam of given pressure and temperature, at a given rate?

What amount of heat energy may be counted on as available in unit weight of superheated steam of given pressure and temperature?

In the greater number of engineering calculations it is the *mean specific heat* that is required, or the average amount of heat needed per degree in changing the temperature of the steam from some assumed starting point to some other temperature. The following table has been compiled from Fig. 7 of the paper as published in the Proceedings of the Society for December:

MEAN SPECIFIC HEAT.

Absolute pressure, lbs. per sq. in.	Superheat, Degs. F. 20°	40°	60°	80°	100°
15	.568	.538	.522	.514	.506
40	.586	.566	.546	.536	.528
60	.614	.580	.562	.548	.540
100	.632	.598	.580	.566	.558
150	.646	.612	.592	.580	.572
300	.662	.630	.612	.598	.590
600	.680	.648	.632	.618	.608

	Superheat, Degs. F. 120°	140°	160°	180°	200°
15	.502	.498	.496	.492	.490
40	.522	.518	.514	.510	.508
60	.532	.528	.524	.520	.518
100	.550	.544	.540	.534	.532
150	.566	.560	.554	.550	.544
300	.582	.576	.570	.564	.560
600	.600	.594	.588	.582	.578

	Superheat, Degs. F. 220°	240°	270°
15	.489	.488	.484
40	.504	.502	.500
60	.516	.512	.508
100	.528	.524	.520
150	.538	.536	.530
300	.556	.552	.546
600	.572	.568	.564

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THE CLASSIFICATION OF CEMENTS

By SAMUEL S. SADTLER

CONDENSED FROM THE "JOURNAL OF THE FRANKLIN INSTITUTE"

With a view of classifying and studying the subject of cements, the writer has prepared the following discussion. This subject is such a broad one, embracing a wide range of chemicals and raw materials, that the scope of this paper can not go beyond a general treatment of the subject.

Besides cements in the narrow sense, there are other preparations which may also be defined and discussed.

A cement is a plastic or liquid substance used to join surfaces. It becomes firm or solid on setting.

A lute is a plastic material used for preventing or stopping leaks and is generally used for temporary purposes. Its setting is generally of such a character that it may be easily removed.

Pastes and mucilages are fluid substances used for uniting paper and cloth or fastening them to surfaces such as wood or metal.

The purposes for which this class of substances are employed are so many that there is hardly any line of work that is not in a notable measure depending upon them. It is difficult to recall any industry not requiring one or more of them.

Wood workers, masons, plasterers, plumbers, bookbinders, machinists, the metallurgical industries, manufacturers of chemicals, all industries where power is a large factor, scientists and householders are constant users of cements.

It can hardly be said that there is any dearth of information as to what might be used in special cases or that there is any difficulty in procuring suitable materials for compounding, but it has been thought desirable to treat the subject in a systematic way. This might help persons to choose a cement, to compound it, and to get the best results in its use.

The fact is that there are hundreds of formulas published for making cements, where dozens would serve if careful selection were made by some one and the results properly classified. Of those now published, too much is claimed for some, others are practically impossible, a large number are unnecessarily complicated or use expensive elements where cheaper ones would serve, such as the use of ale or brandy as media of solution. These substances may do the work required, but simpler ingredients naturally suggest themselves and the old formulas should be revised accordingly, provided tests show that the changes are safe ones to make.

SETTING.

To use cements properly it is quite important to understand the rationale of their action. With this knowledge, if the action characteristic of its setting does not proceed satisfactorily, modifications of temperature, dilution or proportions may be made and much trouble saved thereby.

The phenomena of setting may be differentiated as follows:

1. Evaporation, loss of water or other solvent.
2. Hydration, taking on the elements of water.
3. Cooling.
4. Oxidation.
5. Vulcanization.
6. Ordinary chemical action.
7. Combination process.

1. Evaporation.—In cases where setting takes place by evaporation there are various considerations to be noted in respect to both solvent, solute materials and insoluble filler if any.

The chief consideration is of course as to whether the materials in solution or combined solution and suspension are chemically and physically resistant to solution, corrosion or abrasion incident to their use. This matter is, however, too full of detail to be taken up at this time. As to the solvent, however, something may be said here.

Layers of cement should not be so deep as to seriously hinder evaporation, especially if the solvent is water. When water is used, unless the time of setting is not important, heat is generally present to expel it, or some corrective filler used, such as Portland cement or plaster. As the solvent goes off cracks are

likely to develop if the mixture is too thin. Fibrous materials such as noted below under the head of fillers are useful for holding it together, and if the body of the cement is of soft material such as oils or soft pitch it is especially desirable to have some inert filler present whether fibrous or not. When the solvent is not water, choice of various organic solvents can often be made. In general methyl (wood) alcohol and ethyl (grain) alcohol dissolve soaps, free organic acids and some of the resins, while the other solvents dissolve, more or less perfectly, fats, oils, some resins, pitches and asphalt.

The most important solvents are here given in the approximate order of volatility (with boiling points):

	Volatility.
Sulphuric Ether	35°C.
Carbon di-sulphide	46°C.
Acetone	56°C.
Chloroform	61°C.
Methyl Alcohol	66°C.
Carbon tetrachloride	78°C.
Benzol	80°C
Petroleum benzine	100-150°C.
Toluol	111°C.
Glacial Acetic Acid	119°C.
Turpentine	156°C.

The order of the solvent power is as follows: Sulphuric ether, chloroform, carbon disulphide, carbon tetrachloride, turpentine, glacial acetic acid, benzol, toluol, acetone, petroleum benzine, methyl alcohol, ethyl alcohol.

The cost of these solvents, in the order of their cheapness follows: Benzine, toluol (straw color), benzol (straw color), wood alcohol, denatured alcohol, turpentine, glacial acetic acid, carbon tetrachloride, acetone, chloroform, ethyl alcohol, sulphuric ether.

Most of these substances are extremely inflammable and form explosive mixtures with air. There are two notable exceptions, however—chloroform and carbon tetrachloride—especially the latter. It will neither burn nor support combustion.

2. Setting by Hydration.—In this case crystalline substances form en masse, by the taking up of water. It is desirable to have as nearly as possible the total amount of water required to secure the greatest density and strength. There should not be too much inert material present to keep the particles of the setting substance apart. The more finely divided the inert material, the less can be used, as the particles of cement itself must coat all the particles of inert material or be between them to effect a bond. If the particles of inert material are of the same degree of fineness, only an equal amount, as compared with cement, can be used. When properly graded as to fineness from five to eight times as much by volume of the filler may be used.

The time for setting may be somewhat reduced by using warm water in very little if any excess and may be retarded by having an excess and by the use of small amounts of certain chemicals; alkaline substances, for instance, delay the setting of Portland cement and plaster. In some cases the entire amount of water cannot be used at once or it dries out somewhat, so that subsequent wetting is necessary.

3. Setting by Cooling.—In this class are considered cements and lutes which are applied in the melted state, such as resins, waxes, bituminous bodies, solid fats and sulphur. The great advantage of using materials in this way is that there is no loss in density as is generally the case where the setting takes place by evaporation. The work they are applied to should be hot, however, or the setting is interfered with.

If the pieces of apparatus to be joined are small it is usually well to heat them well, as applying the cement hot is not enough to insure a fused union of cement and work.

Inert substances are almost invariably used in admixture to make the cement harder, stronger, fill voids and to cheapen it. Clay, sand, asbestos, cement, plaster, whiting, etc., are used in this connection.

Sometimes there is a subsequent chemical action, as when acid resins are used with fillers of a more or less basic character, such as metallic oxides or carbonates.

4. Setting by Oxidation.—This may take place in oil used or in powdered metal. In the case of oil there is an effect of hardening and consequent setting. With metals it causes an expansion due to increase of volume. The commonly used oils acting in this way are Chinese wood oil, linseed oil, rapeseed oil and fish oils. In the case of Chinese wood oil, the oxidation is so energetic that it is generally best to mix it with some other oil. Linseed oil is almost always previously "boiled" before use and rapeseed oil "blown."

With regard to the metal powders, iron is the chief one used, although precipitated copper has been used and other metals might be for special purposes. The iron used is inva-

riably the powder resulting from the crushing and sorting of cast borings, filings or millings. They should be nearly free from oil, and the cement has the greatest expansive power when in a finely divided condition.

The value of these cements depends on the expansion taking place in a confined space, such as holes or cracks in castings. This expansion may be so powerful as to break or shatter the object upon which it is used. In such cases it can be diluted with clay or cement. When the holes in a casting are well filled with concentrated iron powder moistened with water containing a very little salt or sal ammoniac the particles adhere so firmly and the actual oxidation is so limited in actual amount, that the casting can be finished and not show where it was mended. Furthermore, the cement is not dislodged by any ordinary means.

5. Setting by Vulcanization.—This takes place where fresh rubber is used as a cement in conjunction with sulphur or certain compounds of the same and heated to about 120° C., which renders the rubber insoluble, firm and causes it to lose its stickiness. Vegetable drying oils may be used, such as rapeseed and linseed oils, with sulphur chloride, dissolved in carbon disulphide, as a vulcanizing agent. Hydrochloric acid gas is liberated in this reaction and so zinc oxide or a similar base is generally used to neutralize the acid. In the vulcanization of rubber itself, such precaution must be taken when sulphur or sulphur chloride is used.

6. Setting by Chemical Action.—Under this classification we have several of the most useful cements known. In most cases, however, the action is too rapid, so that setting takes place before the cement is in position. Dilution of the active ingredients is the general remedy for this. There are also specific ones. As examples of the most useful cements, the oxy-chlorides may be mentioned, which remain nicely liquid or plastic for ample time to use and then set up very strong and hard. The well-known glycerine-litharge cement acts nicely in this respect. Cements formed from silicate of soda and oxides of lime, magnesia, zinc, etc., and those formed by the action of their oxides on casein and albumen do not act so well. They are liable to set up too soon and be crumbly when set up.

7. Setting by Combined Action.—The most prominent case of this kind is the setting of glue. In the first place when used it is a melted mass that on cooling has fair strength of coherence and adherence. Then, however, as the water is absorbed by the wood or other material being cemented, it becomes stronger until very great strength is developed when free of water.

Other cases are when a solvent or heat is used with a resin, boiled oil, etc., mixed with a metallic oxide such as lime. There is then the combined action of the evaporation and the formation of new compounds or so-called metallic soaps.

INERT SUBSTANCES.

These useful, harmless substances do not make a cement, but so many formulas differ only in the choice of them that it might be supposed they did. Sometimes a little work is required of them, as when there is a little water to be taken up. Plaster and Portland cement serve this purpose. Zinc oxide and other basic substances, while mainly serving as fillers, absorb acid in addition. In most cases, however, no action of this kind is required and it is merely a matter of giving body or other physical properties.

A classification of fillers may be made as follows:

Corrective.	Porous.
Portland cement.	Infusorial earth.
Plaster of Paris.	Magnesium carbonate.
Zinc oxide.	
Lime.	
Whiting.	
Magnesia.	

Strength.	Finely Divided.
Asbestos.	Cement.
Hair.	Clay.
Plush trimmings.	Plaster.
Cloth.	Gypsum.
Tow.	Whiting.
Oakum.	Silica.
	Powdered glass.
	Powdered fluorspar.

COMPOSITION OF CEMENTS.

Cements that have come into use to any extent may be placed in classes according to their composition as follows:

1. a. Rubber solutions.
   b. Gutta percha solution.
   c. Pyroxylin solution (collodion).
   d. Gum resin solutions (such as mastic and copal).
2. Silicate of soda and neutral fillers.
3. a. Flour pastes.
   b. Starch pastes.
   c. Dextrin pastes.

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d. Gum solutions (such as arabic, tragacanth).

4. a. Plaster of Paris.
   b. Portland cement.
5. a. Bitumens (pitch, tar, asphalts, etc.).
   b. Resins (resin and gum resin in melted state).
   c. Sulphur.
   d. Shellac.
   e. Rubber and gutta percha, melted or thinned with oil.
6. Iron powder compositions.
7. Drying oil mixtures.
8. Oxy-chloride cements,
9. Glycerine and sugar compounds of lead.
10. a. Glue.
    b. Casein.
    c. Albumen.
11. Cements made from metallic oxides and strong acids.
12. a. Vitreous and vitrifying mixtures.
    b. Clay and asbestos, etc., with water.

Class 1—a, b and c are especially waterproof, tough and tenacious. d is not so tenacious but answers the other requirements, adheres better to smooth surfaces, has greater hardness when set, and is transparent in thin layers in which it is frequently used for optical purposes. a, b and c are generally made up with fillers to prevent the formation of voids on the evaporation of the solvent.

Class 2. Not waterproof, but form very dense, hard and strong lutes. Especially good for hot gases, in which case the water of the silicate can go off. They are useful for organic solvents and stick only too well to glass. Suitable fillers are barytes, whiting; silica, powdered glass and powdered fluorspar. The three latter probably slowly react with the silicate with beneficial results.

Class 3. Are used for fastening paper and cloth.

Class 4. This is a most important class. a is generally used without filler, although frequently mixed with alum, etc., for purposes of increasing the density. It is used for filling hollow articles, moulds, etc. b is the most used of all cements. It is made into concrete for building purposes, etc. For use in small amounts it is not successful as the water dries before it can set.

The making of cement concrete waterproof is an art not understood by all. The main points to be considered are to have the voids as few as possible and the dense coating on the side the water would enter. Neat cement is probably most used for this denser coating. It should be used as strong as it will flow well into crevices and hot if possible. The condition of the work and the kind of cement are important. It is waterproofed best when fresh, and if washes such as silicate of soda, skimmed milk and casein solution are used an over-limed cement is desirable. Magnesia cement has been recommended for this purpose, but the chloride is liable to soak in and not combine properly with the oxide.

Class 5. This is a very important class, if the number of formulas are a criterion. The materials must be applied in melted condition. The marine glues are made from materials of this class. Sulphur is much used by itself and sealing wax is also of this class.

Class 6. The use of this material has been referred to above.

Class 7. Putty and red lead compositions are among the best known cements. Boiled linseed oil is invariably used and if resin is dissolved in it and metallic oxides mixed therewith a much thicker composition is obtained thereby than otherwise. When films of linseed oil are very much oxidized by exposure to heated air and mixed with powdered cork, etc., linoleum can be produced.

Class 8. Oxy-chloride of zinc has been used for dental purposes and forms a very dense strong, stone-like cement. Oxy-chloride of magnesium is, however, more used, as the ingredients are cheaper. It is used for uniting particles of stone either for refacing the same or making an artificial stone, and for making compositions with sawdust for a kind of floor tiling.

Class 9. This class is a valuable one, embracing the well known glycerine and litharge cement, much used for joining glass to metals, etc. It is waterproof, acidproof, gasproof and not attacked by organic solvents.

Class 10. Casein and albumen form very strong compositions with lime, zinc oxide, etc. They set up very quickly, so must be used at once. They are more in the nature of lutes than cements, properly considered.

Class 11. The combination of zinc and other oxides and phosphoric acid stands for this class. It is much used by dentists and forms a hard, dense, waterproof substance.

Class 12. This class includes glass powders or glass forming mixtures that bind surfaces at high temperatures.

With a view of choosing a cement only the most general statements can be made here.

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The following suggestions may be of use, however, the numbers referring to the classification given:

Hot surfaces, 2, 4a, 9, 10 and 12.
Elastic, 1a, 1b.
Water and steam, 5a, 5b, 5e, 6, 7 and 9.
Strength, 2, 4b, 8, 9, 10a and 12.
Expanding, 4b and 6.
Quick setting, 10.
Acidproof, 1a, 1b, 1c, 2, 5a, 5b, 5c, 5e, 9.
High temperature (moderate), 4b, 6.
High temperature (excessive), 12a, 12b.

THE APPLICATION OF HIGHLY SUPERHEATED STEAM TO LOCOMOTIVES

By ROBERT GARBE

FROM "THE ENGINEER," LONDON

Among the improvements in locomotive construction none has excited greater interest in professional circles than the application of highly superheated steam in current locomotive practice. Ten years ago few even among the most far-seeing of practical locomotive engineers were willing to admit of the possibility of permanently and regularly producing steam at temperatures of 550° to 650° F. within the restricted capacity of the ordinary locomotive boiler, and of its safe and economical application to the ordinary running of the engine; while at the present time it has found successful application in more than two thousand locomotives, if we include those in construction with those actually running. Dry or moderately superheated steam has been tried on different occasions, but without realizing any notable economic advantage in practice; and it was not until Mr. William Schmidt, of Cassel, had developed practical methods of applying high superheat that its use became possible in stationary engines about 1880, while fifteen years later, in 1895, the first steps were taken in extending it to locomotives. In the latter connection special notice must be taken of the services of the Prussian State Railway department, which, on the author's suggestion, was the first to sanction trials of the Schmidt system on a large scale on the locomotives under its control.

From the beginning of these trials it became apparent that an effective locomotive superheater could only be realized by making it a closely connected integral part of the boiler itself, receiving its heat from the live flames of the fire-grate and not from waste gases or an independently fired apparatus. This fundamental principle has been retained in all the Schmidt locomotive superheaters, as well as in the numerous modifications derived from them.

PROPERTIES AND ADVANTAGES OF HOT STEAM.

Hot Steam.—According to Schmidt the term "hot steam" is to be understood as meaning steam that has been raised to 100° C. (180° F.) above its proper saturation temperature, by subjecting the steam to extra heating in an enclosed vessel—the superheater—which is in communication with the steam generating space alone, but isolated from the water in the boiler. This has the effect of drying and increasing the temperature of the steam produced by the initial evaporation whereby its volume is increased, but without augmentation of its initial pressure. An appreciation of the method of producing and using the superheated steam will be much facilitated by a preliminary consideration of the more important properties in which it differs from saturated steam, as contained in the following paragraph:

Specific Volume.—The specific volume, i. e., the volume per unit of weight—cubic feet per pound or cubic meters per kilogram—of sat-

urated steam diminishes with increase of temperature and pressure, while, on the other hand, V the volume of superheated steam increases nearly directly in proportion to the rise in temperature. Thus, for steam of 185 lbs. per sq. in. pressure absolute—

At	374°	482°	572°	622° F.
The specific volume is	2.48	2.83	3.14	3.46 cu. ft. per lb.

Or for a superheat of 200° the increase in specific volume is approximately 25%. For the same cut-off in the cylinder, therefore, the weight of steam required is about 25% less with 200° superheat than with saturated steam of the same pressure.

Thermal Conductivity of Superheated Steam.—This augmentation of volume is, however, a less important advantage than that realized by the suppression of all cylinder condensation when the superheat is sufficiently high. While under ordinary average working conditions with saturated steam about 35% of the total quantity admitted is immediately precipitated without doing any mechanical work, and passes through the engine as suspended water in the steam; hot steam, on the other hand, may by reason of its reserve heat be reduced considerably in temperature without losing any of its capacity as a working agent. In this direction another important advantage comes into play, namely, its low thermal conductivity. Highly superheated in contradistinction to saturated steam is a bad conductor of heat. This property, which is of great value in reducing the loss by cooling in the cylinders, is, on the other hand, an obstacle to the free transmission of the heating agent to the steam in the superheater, and calls for special consideration in the design of the latter.

Calorific Value.—Total Heat Value.—In order to realize the great economical advantages of hot steam, increased volume and avoidance of cylinder condensation, a certain heat expenditure is required which must be debited to the saving due to the above items.

The heat necessary to raise 1 lb. of saturated steam from its proper temperature t_s to the higher temperature t deg. F., is

$$W_1 = C_p (t - t_s) \text{ B.T.U.}$$

C_p being the specific heat of the superheated steam under constant pressure.

Putting W = to the quantity of heat contained per pound of steam saturated at the particular pressure as contained in Regnault's tables,

$$W_2 = W + W_1 = W + C_p (t - t_s)$$

expresses the heat value of the superheated steam; that is, the total heat contained in 1 lb. of the steam superheated to the temperature t.

Size of Superheaters.—The heat requirements of the superheater are not limited to the amount W_1 necessary for supplying the actual superheat, but must be supplemented by the quantity required for evaporating particles of water carried over mechanically in the superheater.

Assuming a degree of humidity in the boiler steam of 7%, which for ordinary locomotive working conditions is certainly not excessive, the heat demand for the production of 1 lb. of steam at 170 lbs. pressure (absolute) and 572° F. temperature from the heating surfaces of boiler and superheater respectively will be as follows:

	B.T.U.	
From the boiler-heating surface—		
0.93 lb. dry saturated steam 0.93 × 1,194.3 = ...	1,111	
0.07 lb. water at saturation temperature, 0.07 × 340.5 =	24	
		1,135
From the superheater—		
Evaporation of 0.07 lb. water at 368.3° F., 0.07 × 853.8...	60	
Superheating 1 lb. dry steam by 204° F., 0.541* × 204..	110	170
Total heat required for 1 lb. hot steam		1,305

of which 170, or 13%, is required for the superheater.

In the normal locomotive boiler with a narrow and deep fire-box having about 10% of direct heating surface,† about 40% of the total heat is developed in the fire-box and the remaining 60% in the tubes. The superheater surface therefore must be 13% of 60, or 22% of the total tube surface; and when it is further considered that the best part of the latter, that is, in the neighborhood of the fire-box tube plate, is unavailable, being previously reserved for evaporative use, it will be readily understood that in order to obtain a sufficient superheat, from 25 to 30% of the total tube surface of the boiler must be appropriated to that use.

It also follows from what has been previously advanced that when the demand due

*From results obtained by Knoblauch and Jakob—see page 143 Vol. II., Technical Literature.

†This excludes from consideration American forms of boiler, which have as a rule, only comparatively small direct heating surface.

to supplementary evaporation, which is practically constant, is taken into account, it by no means follows that superheated surface is directly proportional to the degree of superheat. For example, for only half the heat, say, to 473° F., considerably more work is called for than would be furnished by a superheater of only half the heating surface.

GENERATION OF HIGHLY SUPERHEATED STEAM IN LOCOMOTIVE BOILERS.

The valuable property of bad thermal conductivity characteristic of highly superheated steam is a source of great difficulty in its production. Steam with only a moderate superheat is generally mixed with particles of water or damp steam, and the better thermal conductivity of the latter facilitates degradation of the mixture, and this tendency only disappears when the superheat is sufficiently high. It is not sufficient to supply heat in approximate quantity through the superheater walls, but means must be adopted to insure that the heat so supplied is brought into contact with the individual particles of the steam current as it flows through the tubes until each one is brought from the saturated to the superheated state. This requires that steam coming in bulk from the boiler shall be divided into numerous thin streams which, by combination with multiple reversals of direction, may insure that moist and superheated particles shall be thoroughly mixed in their passage through the superheater tubes.

It is further necessary, having regard to the low conductivity of superheated steam, that in order to effect the necessary heat transfer to the rapidly flowing steam particles in the superheater, a high temperature difference shall prevail; that is, the application of highly heated gases is essential.

If the steam is only improperly heated, that is, if it contains both superheated and wet portions, the temperature indicated by the thermometer will be that of the average of the mixture, and it will therefore be erroneous to assume that this will be that of the steam as a whole considered as at a uniformly medium superheat. In reality, saturated steam particles, with their prejudicial tendency to the cooling of the superheated portions, are still present, and the anticipated economic advantage in the engine can only be imperfectly realized.

According to the author's experience, an average temperature of 570° F. in the slide-valve chest must be attained in order to insure the homogeneity of the superheated steam or its freedom from intermixed damp or saturated portions; repeated trials having shown that the coal and water consumption are decidedly increased whenever the temperature falls below that level to any appreciable extent.

The essential conditions determining the saving in fuel are to be defined as follows:

1. The difference in specific volume between the two kinds of steam.
2. Their different heat values.
3. The humidity of saturated steam.
4. The alteration in cooling losses in consequence of the higher temperature and lower thermal conductivity of superheated steam.
5. Changes in the relations of firing and blast pipe conditions and in the thermal radiation of the boiler.

Of these points the last three cannot be brought into calculation, and therefore must be excluded from the theoretical investigation of possible saving of fuel and feed-water which involves the following assumptions:

(a) That the boiler efficiency of both engines is the same.

(b) That the engine is a heat-proof structure not subject to losses.

(c) That the steam from the non-superheated engine is in the dry saturated state.

Theoretical computations of the thermal economy are only possible when the points 1 and 2 are assumed as bases. The results of such a calculation may be summed up as follows:

THEORETICAL ECONOMY IN COAL AND WATER OBTAINABLE BY SUPERHEATING STEAM TO 572° F. FOR Cp. = 0.48 AND 0.6.

Steam pressure excess.		Theoretical saving. Water. Cp. = 0.48. Per cent.	Coal. Cp. = 0.6. Per cent.
170 lbs.	Saturated / Superheated	11.0	4.0	2.2
142 lbs.	Saturated / Superheated	13.3	6.1	4.3
114 lbs.	Saturated / Superheated	15.0	7.2	5.3
85 lbs.	Saturated / Superheated	16.8	8.6	6.3

The principal point of interest in this table is the clear manner in which the value of superheating is brought out, the highest absolute superheat with the lowest steam pressure, 85 lbs. (572° − 327° = 245° F.) showing the highest theoretical saving both in fuel and water.

The actual saving can, however, only be deduced from such theoretical results by introducing corrections for the losses resulting from cylinder cooling and humidity in the ordinary locomotive, and these must be based upon more or less arbitrary assumptions, whereby the practical value of the result is en-

tirely lost. The practical man, therefore, can only rely safely upon the results obtained in propery conducted trial trips.

HAULING CAPACITY OF THE HOT STEAM LOCOMOTIVE.

(d) In addition to the saving in fuel and water, a further and more important advantage of hot steam working is to be found in the notably enhanced hauling capacity of the engine.

In comparative trials of a four-coupled ten-wheeled, four-cylinder compound against a similarly coupled eight-wheeled two-cylinder engine with Schmidt superheater, doing equal work, the latter has often shown a saving of about 25% of coal; and when by harder driving about 40% more work was got out of it, the consumption was still about 10% less than that of the compound. From such results the following simple practical conclusions may be deduced:

Supposing that for equal tractive effort in the two engines, which, in the compound, represents about the maximum, and in the superheated engine only about the medium power, the saving in coal by the latter to be only 20%, the work for equal quantities of fuel burnt under similar conditions may, by superheating, be increased $\frac{100-80}{80} \cdot 100 = 25\%$.

As, however, under present working conditions as to speed and dimensions in four-cylinder compound express engines, about 40% of the indicated horse-power developed in the cylinders is consumed in engine and running resistances, leaving only 60% for drawbar effort, the 25% becomes $\frac{25 \times 100}{60}$ or about 40% at the drawbar. An increase which, as already stated, has been repeatedly obtained in comparative trials. When the comparison is made with a two-cylinder engine of about the same or somewhat larger weight, the advantage in favor of superheating is still more marked, it being, of course, understood that the cylinder dimensions and superheating conditions are correct.

We have, therefore, in superheating a means of meeting the continuously increasing demand for higher speeds and heavier trains without having recourse to abnormal increase in the dimensions of locomotive engines and boilers upon those now current.

In ordinary working the saving of coal by superheating is somewhat less than that shown in comparative trials, where a principal purpose is the determination of the maximum tractive power of the engine under trial. When this point, which has been the subject of numerous criticisms in professional circles, as determining the true value of superheating, is considered, it must be remembered that in current working the time-tables are so arranged that the saturated steam locomotives may run under comparatively economic conditions at or near their full power while the more powerful superheated engine of the same weight would be doing the same work with considerable reserve power. When, however, the wet steam engine is beyond its normal power the point of exhaustion is approached, coal and water are blown out of the chimney unused, and the only resource left is double heading. The superheating, therefore, is to be regarded not merely in the light of saving 25 to 30% of coal, but as a certain security against the wasteful and objectionable practice of using two engines in front of one train.

The principal advantage of hot steam, therefore, is to be realized with heavy loads at very high speeds, as with increase of speed the work consumed in engine and air resistances continuously increases, and these resistances are considerably lower in the plain superheated steam engine.

The considerable augmentation in working capacity by superheating which has been found in all trials hitherto carried out is of much greater importance to the locomotive department than even the largest saving in coal and water, and should be the point of primary consideration, and the more so as the equal economy for minimum as well as maximum work would allow of a reduction in the number of different classes of engines in use for different services.

FLUE-GAS ANALYSIS: ITS VALUE

By J. W. HAYS

CONDENSED FROM "POWER"

Much is being said and written about flue-gas analysis, and automatic instruments for the analysis of gases have recently appeared upon the market. The prominence with which the matter is being brought before the engineering eye causes an inquiry into the real economic value of gas analysis to be charged with particular pertinence at this time. As the value of it is over-estimated in some quarters and under-estimated in others, the inquiry assumes even more importance.

The impression is too widely prevalent that a machine for analysis and a hole in the breeching for a sampling pipe are all the equipment an engineer requires to render him expert in the regulation of the furnace fires. Of what value is an indicator diagram, if the engineer is unable to read it? Of what value is the chart from a CO_2 recorder, if the engineer is unable to interpret it correctly? To tap the gas passages at any point, such as the breeching, and find any given percentage of CO_2 (4%, for instance) does not necessarily indicate anything as to furnace performance. Correctly interpreted, the results from an analysis of the escaping flue gases may be of the highest value to the engineer. It is only by such analysis that the highest economy in furnace operation may be attained and maintained.

To increase furnace efficiency is the sole aim and end of flue-gas analysis. It is not concerned with any other consideration. When a quantity of air just sufficient for the operations of combustion is permitted to enter the furnace, efficiency will be at the highest point attainable. If the air supply is decreased, combustion will be incomplete. Unutilized heat units will go up the chimney. If the air supply is increased, the excess air will cool the furnace by the absorption of heat units, and energy that might otherwise express itself at the piston of the engine will be wasted upon the atmosphere.

Oxygen constitutes about 21% of the air by volume. If carbon should be burned with only the theoretical quantity of air, all of the oxygen would unite with carbon, and we should have 21% of carbonic acid gas, or CO_2, in the escaping chimney gases. As some surplus air is necessary in actual furnace operation, owing to the difficulty of securing a prompt and thorough mixture of the admitted air with the combustible furnace gases, we are forced to be satisfied with a maximum of from 15 to 17% CO_2 and a minimum of from 4 to 6% free oxygen. Anything short of these figures represents something less than possible attainment. When all the exigencies connected with boiler furnace operation are considered, an average for the day's run of 12% CO_2 may be counted very satisfactory. The average steam plant will be unable to show an excess of 7%. This is the efficiency of ordinary methods of furnace operation.

With a proper instrument for gas analysis correctly operated and the findings understandingly interpreted, 12% CO_2 can be easily attained. The difference in economy between 12% and 7% is around 11% in fuel.

It is most unfortunate that builders of automatic instruments for furnace-gas analysis have so riveted their eyes upon the CO_2 that the importance of oxygen determination has completely escaped them. Oxygen is the cause, the other elements represent the effect. If the oxygen content is what it should be, the proper amount of CO_2 will usually be found in company. The CO_2 recorder determines carbonic acid gas for the purpose of inferentially arriving at a conclusion with respect to oxygen. The inference, which is often wrong, might be avoided if oxygen were directly determined.

The ideal apparatus will determine and record both CO_2 and oxygen. The sum of the percentages of these two gases should approximate 21; if less than 21, the difference may be assumed as due to the presence of carbonic oxide and other combustibles. Such a state of affairs requires either more oxygen or better admixture of the oxygen with the combustible gases. The percentage of oxygen carried, as indicated by the chart which accompanies such apparatus, will enable the engineer to determine at once which is the case. If the oxygen exceeds by about 5%, the fault is due to lack of mixture; if it is less than 5%, the fault is due to lack of oxygen.

The single analysis machine—that is, the

apparatus analyzing for and recording only CO_2—registers the complaint that something is wrong. Such a machine puts it "up to" the engineer to discover what is wrong.

The compound analysis machine—that is, the machine analyzing for and recording both CO_2 and oxygen, when someone produces it—will not only indicate trouble, but tell the engineer where the trouble lies, whether due to excess or deficiency of air or lack of proper admixture with the combustible furnace gases.

If flue-gas analysis is contemplated as a test of economy, the location of all air leaks should be the first concern of the engineer. Until this has been done, it cannot be assumed that any analyses of gas taken from the breeching are indicative of the real conditions of furnace performance.

The present movement toward gas analysis is probably the most important occurrence since the search for economies was first instituted in the boiler room. Gas analysis is the only conclusive test of furnace efficiency, but like every other form of test care must be taken to eliminate all possible causes of erroneous conclusions.

THE PROPOSED HENRY HUDSON MEMORIAL BRIDGE

CONDENSED FROM "ENGINEERING NEWS"

Plans have been prepared by the Department of Bridges of New York City for a concrete arch bridge of remarkable size. This is the bridge proposed to be a tercentenary memorial of Henry Hudson's voyage up the river that now bears his name. It is to cross the western end of Spuyten Duyvil Creek (which separates Manhattan Island from the mainland to the north) and will form a part of New York City's elaborate driveway and park system on the bank of the Hudson, the Riverside Drive. The object of the bridge, to serve as a monument of an important historical event, calls for a monumental structure, of course, and every endeavor was made in the design to fulfil this need.

The movement for a Hudson celebration and a permanent memorial was originally stimulated by a private association of citizens, who early settled upon a high-level bridge over Spuyten Duyvil Creek as the most appropriate memorial. Their agitation finally resulted in the city's accepting the proposal, and committing itself to the bridge project.

This design employs concrete for the principal elements of the structure, the width of the span being 703 ft. in the clear. In steel, a span of this magnitude is substantially within the limits of approved construction (the upper Niagara arch, 840 ft. c. to c. of hinges, is the largest existing steel arch; the design for the Hell Gate bridge contemplates a 1,000-ft. arch). But in concrete there is nothing even remotely approaching in magnitude the proposed span. The Grünwald bridge over the Isar at Munich, Germany, 230 ft. in span, is the largest completed concrete arch. The Walnut Lane concrete arch bridge, now being built, has a slightly longer span, 233 ft. between faces of abutments. These spans become insignificant, even trivial, when compared with that now proposed for the Hudson Memorial Bridge.

A better idea of the boldness of the proposal is had from a comparison with the general field of masonry arch construction, since the problems of design and erection for arches of stone and concrete are in a measure the same. The Cabin John arch of the Washington aqueduct, 220 ft. in span, built about half a century ago, was for a long time looked upon as an exceptional achievement, being the largest stone arch in the world. Only in the last eight years has it been exceeded, and there are now three larger spans in stone, besides the 230-ft. concrete arch at Grünwald: Adda, 230 ft.; Luxemburg, 278 ft.; and Plauen, 295 ft. In fifty years, designers have ventured only one-third beyond the limits set by the Cabin John arch, and only in three cases have they found it necessary. Now, in one leap, the present limit is to be multiplied by two and one-half.

The design for this remarkable structure

THE CUTTER "MARIE" (MR. J. G. ALEXANDER).

The roadway on the approaches has a grade of 1½% from either side up toward the center; over the main span a vertical curve unites the slopes. By adopting this gradient, a notable gain in center height of arch was secured, as compared with the first design, and the arch stresses correspondingly reduced. The 100-ft arches are of concrete, probably unreinforced. The piers between them, detailed to harmonize with the treatment of the two main piers, are faced with stone in rusticated coursing. All other surfaces of the structure are concrete. This is expected to give a marked relief between the pier faces and the arch and spandrel faces.

The arch rib is practically a circular segment in the profile of its center line. The center-line radius is 450.94, except for a short distance at the crown which has a slightly greater radius, 489 ft. The other principal dimensions have already been given, but together with the governing conditions as to load, etc., they are tabulated here:

Span, c. to c. skewbacks	725 ft.
Rise, c. to c.	177 ft.
Width of ring	70 ft.
Crown thickness	15 ft.
Skewback thickness	28 ft.
Reinforcement, mean	abt. 1¾%
Live-load	15,000 lbs. per lin. ft.

[Roadway and sidewalks, 75 lbs. per sq. ft. on 80-ft. width; four railway tracks, 2,250 lbs. per lin. ft. each.]

Temperature variation	±20° F.
Maximum shrinkage allowance	1 5000

The estimation of dead-load, the determination of ring thickness, and the proportioning of the curve of rib, were the result of successive approximations. The influence of the live-loads in shifting the pressure line is so small that the live-load moments had very little bearing upon the ring thickness. The limiting compressive unit-stress in the concrete was the most weighty factor; the two objective points of safe maximum stresses and least combined cost of steel and concrete were attained by adjustment of both the ring-thickness and the reinforcement percentage.

A concrete at least as rich as 1:2:4 was decided to be used, and for this the permissible compression, all sources of stress considered, was fixed at 750 lbs. per sq. in., the working stress allowed by the Bureau of Buildings of Manhattan Borough, New York City, for semi-looped reinforced-concrete work.

The computation of stresses was carried out on the basis of exact elastic analysis. Both a graphical and an algebraic calculation were made, being checked against each other both in the location of the several pressure lines and in the stresses.

In all the calculations, the modulus of elasticity was taken to be 1/15 that of steel; calling 30,000,000 the modulus for steel, the concrete was credited with a modulus of 2,000,000 lbs. per sq. in. Then with 750 lbs. unit-compression in the concrete, the steel reinforcement is stressed to 11,250 lbs. per sq. in. as a maximum. This figure is subject to modification, however, to allow for the fact that the steel carries its own weight, and for the unequal distribution of the shrinkage of the concrete as the construction work progresses.

Since the arch ring is never required to resist tension, the steel which is put into the ring is not strictly reinforcement, in the sense of tensile reinforcement. No direct static conditions governed the proportioning of this steel work, therefore. The steel is employed primarily to ensure structural integrity or homogeneity of the entire arch ring, and being once provided, it was applied to the purpose of reducing the compressive stress in the concrete. Since steel costs much more than concrete, a minimum amount of steel was desirable. The conflicting requirements were harmonized by successive approximations, which were begun with a crown thickness of 12 ft., and developed by repeated modification on the basis of the calculated extreme-fiber stresses and total costs. The final result is a steel percentage which will probably average about 1¾%. The distribution of the steel to suit the variations of total arch stress, however, will make the percentage at different sections vary from about 0.6% to about 2.9% at the crown.

The weight of the steel in the arch, including columns and deck, counting a length of 750 ft., is about 12,000 tons; about 8,500 tons of this is in the arch ring. These figures are quite roughly approximate, of course. They are intended to include the weight of bracing and details, taken as 40% of the main sections. The corresponding volumes of concrete are 75,000 cu. yds. and 47,000 cu. yds., the former of which includes the foundations.

The total length of the bridge, including the approaches, is 2,840 ft. Its cost, excluding special ornamental features, is estimated at $3,800,000. About one-half of this is chargeable to the large arch and its superstructure.

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The design of the bridge was carried out by the organization of the Department of Bridges of the City of New York, Mr. J. W. Stevenson, Commissioner of Bridges, Mr. C. M. Ingersoll, Chief Engineer, Prof. Wm. H. Burr, Consulting Engineer, Mr. Whitney Warren, Consulting Architect, and Mr. Leon S. Moisseiff, Engineer in Charge.

SANITARY ENGINEERING*

By R. B. OWENS, B. A., B. E.

WATER SUPPLY.

Next to pure air, a good supply of pure water is the greatest necessity of life; evidence is continually forthcoming to prove that shortness of water supply means increase of disease; the lowest amount compatible with health and cleanliness is about twenty gallons per head, per day, but forty gallons is really necessary; one hundred to one hundred and fifty gallons is said to be supplied in some American cities, but taking into consideration the important question of the disposal of sewerage, this quantity seems to me to be excessive, and where such is the case, water meters ought to be installed and the amount cut down to that necessary to supply all reasonable needs.

The chief sources of water supply are wells, rivers and upland gathering grounds. Shallow wells are the most common source of supply in country districts; these are dug in the ground until an impervious stratum of hard clay or rock is reached, and then sometimes a short distance into such stratum. The water obtained in such wells is that which has percolated downwards through the upper layers of porous earth, sand or gravel until it has met with this impervious stratum, beyond which it cannot pass. There is always a great danger of organic matter being washed from farmyards, stables, manure heaps, cesspools, privy pits, etc., through these porous layers to the surface of the impervious stratum and travelling slowly great distances on this surface until a hole in the stratum in the form of a well is reached; here it remains and if it does not in itself contain the germs of disease, it provides just the proper media for the cultivation of such germs as may, and do, find their way from the surface of wells by the trickling of water down the suction tube. It is thus imperative that wells in country districts should be what are known as "deep wells," i. e. wells that reach down to a lower store of water, and catch that which has found its way through an outcrop of the stratum at a high level in some uncultivated and uninhabited district down to a level below the impervious bed upon which the subsoil water rests. It must of course be insured that such a well is properly constructed and lined with brickwork set in cement from the very top down into the impervious stratum where boring begins, or better with earthenware tubes of large diameter made for the purpose in short lengths with bevelled edge to secure good joints, and the top of all wells should be brought above the surface, securely covered and evenly rounded off with a layer of puddle clay, and the discharge pipe should be about fifty feet in length, in order that the overflow from troughs, etc., around which animals drink, should not trickle down the suction tube into the well.

For the supply of towns, several sources of supply are resorted to. Deep wells are sometimes made by driving iron tubes of a diameter varying from 1¼ to 4 ins., according to the needs of the individual cases; and sometimes by drilling or boring into the impervious stratum and lining with iron pipes backed with cement according to circumstances; wells of the two kinds last mentioned cannot, under ordinary circumstances become contaminated with surface washings. These are driven in groups, the number of which varies according to the amount of water required; an increase in demand should be met by an extension of the system rather than by over forcing, for the latter will cause an undue lowering of the water level and tend simply to bring water downwards from the upper strata. Under exceptional circumstances even these deep wells may become contaminated by filth which gains access through such channels as cracks and fissures in impervious strata.

*From a paper read before the Union of Alberta Municipalities, at Medicine Hat, Sept. 18, 1907, by the Provincial Sanitary Engineer.

Filter galleries.—These are sometimes constructed. They are in reality nothing more than horizontal wells sunk parallel and near to a river or lake. Although this method of obtaining water has been attended by most excellent results, yet the fact remains that the water so collected comes not from the river, but from the ground on its higher side, and this method is thus subject to contamination such as shallow wells are. The water of a river or lake, does not, except under exceptional circumstances, percolate outwards, for the silt deposited in its flow clogs the interstices in the soil of its bed and acts as a valve against its egress; the ground water flowing to the river, finds its way through the silt which gives way towards on the side of least resistance.

Rivers and streams are very common sources of supply; such water is excellent provided no contamination from animal matter has reached it; but unfortunately, towns, villages and houses situated anywhere near a river, nearly always pour their waste and impurities of every kind into it, as do also barges, gravel dredges, etc., and the water, pure at first, becomes horribly polluted as it goes along. It is true that there exists in all running water certain natural agents for self-purification, and that the influence of sunlight, air, movement, the action of bacteria and water plants, tend to render all animal matter harmless. But opinions differ as to the time required for such influences to avail and also upon the extent of their power.

It is usual now in places where regard is paid to public health (and the fact is realized that nothing is in the long run more expensive than disease), to obtain a good supply of pure water at all costs from a catchment area in some highly situated and uninhabited district. In order to do this the water can be taken from a natural reservoir, or an artificial reservoir can be constructed at the bottom of a valley and all the water as it comes down from the neighboring hills impounded, or the head waters of a river can be captured and stored in a reservoir, or an unnavigable river can be dammed. This catchment area source of supply is the most safe and satisfactory of all, but those who arrange to get water in this way should obtain such a control over the catchment area as to be able to prevent absolutely the erection of dwellings thereon. This is important by reason of the fact that should excreta from a person suffering from typhoid fever be emptied on a catchment area, an epidemic amongst the water consumers would be almost sure to follow.

In Belfast, Ireland, both the old and the new systems are on this principle, but some years ago the catchment area of the old system contained dwellings and farms. The farmers when they came to the city, used to buy and eat shell-fish gathered in certain seasons on the shores of the Lough, which is an arm of the sea, wherein at that time the sewage of the city and other smaller towns was discharged in a raw state. Some of these farmers after eating the shell-fish would become ill with typhoid and it was noticed that when such a case occurred on the catchment area, after a short time an outbreak of typhoid in the city itself would take place. This compelled the commissioners to purchase outright and remove from off the catchment area all the dwellings, etc., thus converting the area of cultivation into a wilderness with the result that the number of cases of typhoid was materially reduced. The new system for Belfast when fully completed will cost seven and a half million dollars to obtain a supply of thirty-three million gallons per day from the Mourne Mountains. Birmingham has recently spent close on thirty-five million dollars to obtain a supply of sixty million gallons per day from Elan Valley, Wales. Edinburgh recently spent about seven million and a half on the Talla scheme, to obtain a supply of twenty million gallons per day. Glasgow obtains its supply from Loch Katrine; Liverpool, from Lake Vrynwry in North Wales. Ottawa is likely in the near future to take its supply from a mountain lake some fifteen miles away, instead of from the river. This method is also the one most frequently encountered in American practice. It is the simplest; it admits of the greatest amount of certainty in determining the quantity and quality of the water and the kind and cost of the work necessary to utilize the supply.

PURIFICATION OF WATER.

What is needed in water supplies is innocence, not repentance, but if an innocent supply cannot be obtained, then the contaminated supply must be purified. The pathogenic bacteria must be gotten rid of, for all of them, and particularly the typhoid bacillus, act as a constant menace. It is also important to get rid of color, suspended matter, taste and odor. There are three practical methods of purification in use, viz.:

(1) Sedimentation of river water stored

in large reservoirs often in a few weeks causes such waters to lose ninety to ninety-five per cent. of their bacterial contents; time is allowed for the suspended matter in muddy water to settle to the bottom. The pathogenic bacteria which are feared in drinking water do not thrive in that medium, but rapidly die; these and other non-pathogenic forms are largely carried to the bottom by their own weight or by the precipitation of other materials.

(2 Aeration.—This method of purification has not been used much but is coming more in favor. It saturates water with oxygen, aids in discolorization, diminishes the free carbonic acid; it diminishes the organic growths for which the carbonic acid forms a food, and removes substances like sulphuretted hydrogen, but its effect is largely confined to tastes and odors, although there are undoubtedly some tastes and odors which cannot be adequately removed by any practicable amount of aeration.

(3) Filtration.—This may be what is called natural or mechanical method. Natural filters consist of a series of beds of sand, about an acre in area—they can be of a larger or smaller of course, but an acre is a convenient size—and of a total thickness of 4 to 6 ft., consisting of several layers, graduating from course material at the bottom to moderately fine sand on top, of about 2 ft. in depth; it is this top layer that is the essential part of the filter and it is necessary to secure sand of the right quality; it should be sharp and even. A system of underdrains at the bottom carries off the filter to the pump well. The filter is filled beneath to drive the air out and the water is allowed to stand for twenty-four hours before the filter is started and the first water which passes through runs to waste. The character of the layer of slime, which is precipitated upon the surface of the sand from the water standing upon it and from that which first passes through it, in a measure determines the efficiency of the filter and also the efficiency of the filter in a general way varies inversely as the rate of the filtration, the higher the rate the less is the water improved by its passage. The filters are cleaned by drawing off the water and scraping about a half inch from the surface of the sand. Constant supervision of filters is nearly always necessary.

Mechanical filters are coming more into use now. The cost of constructing one of these filters is considerably less than the cost of the natural filters, particularly if the natural filters have to be covered. Such a machine consists chiefly of an iron or wooden cylinder fitted with coarse sand or crushed quartz, through which the water passes by gravity or is driven under pressure at a very much greater rate than it moves in a bed. To take the place of the sediment layer which forms in the other, an artificial film is produced by the use of alum as a coagulant. With careful management a very large percentage of the bacteria are removed.

Aeration and filtration combined form a highly desirable method of purification; it is being used in several places. At Charleston, S. C., an aeration and mechanical filtration plant has recently been installed. One system embracing the three, sedimentation, aeration and filtration is excellent. Along rivers, deep, narrow coulees can sometimes be found where dams could be constructed to form large sedimentation reservoirs cheaply; to these could be added aeration and mechanical filtration plants. The water of the river could be pumped to the sedimentation reservoirs, where after remaining some time it could be passed on to the aeration and filtration plant, and thence to the pump wells, whence it can be pumped to the stand pipe for distribution; or, sedimentation reservoirs can be situated on low lands near the river where water can be allowed to enter by a sluice. However, local circumstances in this, as in other schemes, would decide the matter.

DISPOSAL OF WASTE.

The next most anxious matter to be considered is the disposal of the waste attendant on human life, the solid and liquid excreta. On one point all are agreed; such materials must be taken away immediately from the vicinity of dwellings by the simplest, cleanliest and most effective means that can be devised. The different methods in vogue are:

1. The dry methods which comprise:—
(a) Privy pits, wooden boxes, cesspools;
(b) Earth closets;
(c) Pail system.

2. The water-carriage method which includes:—

(a) The combined system of sewerage, where all sewage, surface water, manufacturers' refuse and subsoil water are carried in the same sewer;

(b) Similar to the above, the subsoil water, however, being carefully excluded;

(c) The partially separate system;

(d) The absolutely separate system.

Let us first consider the systems employed under the dry methods (although none of them are suitable for large communities), afterwards the systems employed under the water-carriage methods.

Privy Pits, Wooden Boxes and Cesspools.—These are things to be early gotten rid of; there is probably no form of nuisance which in the aggregate causes so much annoyance. They are not only nuisances, but they are also real menaces to health. The excrements in cholera, typhoid and perhaps in other diseases contain large numbers of pathogenic germs, and in fact it is only through the excrements that cholera and typhoid are spread. The soakage from these often pollutes the stratum from which drinking water is taken.

Earth Closets.—These are being used in various forms, but they are more complicated than the method known as the

Pail System.—This, if not from the scientific point of view quite so correct as earth closets, is, on account of its simplicity, an effective method of disposal. But even a pail closet ought not to be maintained on any lot for the accommodation of which a public sewer is available. A pail closet should be at least 5 ft. from the line of an adjoining lot, 2 ft. from any street or private or public passageway, 10 ft. from any building or place of business, and 50 ft. from any well or spring likely to be used as a source of water for drinking or domestic purposes. It should be constructed and maintained in such a manner and position as to afford ready means of access thereto for the purpose of cleaning it, and so as to permit the removal of the contents from the privy to the public street without carrying them through any dwelling house or place of business. The receptacle should be movable; there should be a floor over the whole area of the space and also immediately beneath the seat, the surface of which should not in any place be less than 4 ins. above the level of the surrounding ground and have an incline towards the door of ½-in. to the foot. Such floor and the whole extent of each side of the space between the floor and top of the seat should be constructed of some non-absorbent material. The seat, the aperature therein, and the space beneath must be of such dimensions as to permit the movable receptacle for filth to be fitted beneath the seat in such a manner and position as to prevent the deposit of filth elsewhere than in the receptacle. The seat should be so constructed that the whole or part of it may be readily removed or adjusted so as to afford adequate access to the space beneath for the purpose of cleaning it. The receptacle should not exceed in capacity 2 cu. ft., be made of metal, water tight, provided with handles, and so constructed that it may be closed with a cover and made air-tight at the time of its removal. With regard to the privy itself, a trap-door should be made at the rear of such a size that the pail may be easily removed; a sufficient opening for ventilation should be made as near the top as practicable, communicating directly with the external air. On the Goux principle, used at Halifax, England, the pails have an abundant lining of dry earth which is shaped by means of a mold for the purpose. The pails are relined at the works after emptying.

The Water-Carriage Method.—This method is rapidly displacing the dry or conservancy method; it seems to accord best with our national customs and ideas. Most certainly no other method is so satisfactory in towns and populated districts.

SEWERAGE.

A good system of water-carriage sewerage should embrace the whole of the following requirements: 1. Each sewer should be laid at such a depth as will readily drain the basements of the adjoining buildings. 2. Its area and gradient should be so regulated , as to make it self-cleansing, and at the same time carry off effectively the maximum quantity of liquid for which it is intended. 3. Such sewer should (unless quite impracticable) be laid in straight lines with even gradients between man or lamp holes, and these gradients should not be excessive, or damage may be caused to the sewer. Sewers should be laid at proper levels in respect of their intersection with each other, bearing in mind that they are generally converging to one point. Manholes should be of simple construction; circular brickwork upon concrete, or concrete entirely is a convenient description. They may be made to serve the additional purpose of ventilating shafts, flushing chambers, junction shafts, storm overflows and side entrances. Tributary sewers and drains should not join the main sewer at right angles unless the bottom of the manhole is so constructed as to give the required curve in the direction of the flow of the sewage and they should join at a height (if of unequal sections) equal to the difference of their sectional diameters, the aim of all junctions being to cause as little dis-

turbance as possible in the proper flow of the liquids along their respective channels. Sewers should not be constructed of too large a sectional area, but none should be less then 4 ins. diameter, and the main sewer not less than 6 ins. internal diameter, as house sewers are never less than 4 ins. diameter, and the main sewer should, of course, be larger than its tributaries. It is also rather difficult to ventilate a sewer smaller than that. Stoneware pipes of greater diameter than 18 ins. should never be used. When large sewers are constructed they should be either concrete pipes, brick work or concrete.

In constructing sewerage works the greatest care is necessary in the selection of materials and the manner in which the work is executed. Municipalities should do all the sewer work themselves by direct labor, no part of the construction should be done by contract; levels should be very accurately given and adhered to. In quicksand or anywhere where a good and quick job is required, patent safety jointed pipes can be used with advantage. In order to connect a high-level sewer with one at a lower level, a ramp should be employed in preventing the evils of a direct fall.

Breakages sometimes occur in stoneware pipe sewers after they are laid, which generally are found on examination to arise from one of the following causes: 1. Laying the pipes on a rigid foundation without recessing the sockets so as to give an even bearing; 2. Laying the pipes on foundations which afterward yield or settle; 3. Laying the pipes at too greath a length without protection by concrete or otherwise to resist the pressure of the superincumbent earth, or by not sufficiently puddling the filling-in, when a sudden settlement will often crack or crush a pipe; 4. Accidental or wilful injury to pipes which is not noticed before the trench is filled in; 5. Defective or weak pipes.

The chokage in pipe sewers generally arises from one or more of the following causes—improper gradients; insufficient flush; foreign articles finding their way into and choking the sewer; defective joints through which the liquid runs leaving solid matter behind; an excess of road detritus finding its way into the sewer; improper bends in the line of sewer; right angle or improper junctions being formed in the sewer; a collapse of the sewer.

The two principal systems employed in the water carriage methods are: The combined, where all sewage, surface water and manufacturers' refuse are carried in the same sewer; the partially separate system where all sewage, manufacturers' refuse and rain that falls on back-yards are carried in the same sewer, while the other surface water is carried separately in either artificial or natural channels.

The combined system as above is the system most generally used. For the design of this system the first data required are the maximum and minimum quantities of liquid that will have to be discharged by the sewers of the proposed system. The minimum dry weather flow may be determined after ascertaining the prospective population to be served, the water supply per head, per day—one-twelfth of which may be assumed to be used in one hour—and any constant trade and other discharges into the sewers. In some towns the maximum flow that will have to be dealt with in the sewer may be then assumed to be some multiple of the minimum, the whole when in excess of this maximum being diverted at various points through storm-water overflow conduits, into the natural water course or stream. For the storm-water overflow conduits and for the sewers in towns where the previous method for its determination is not applicable, the maximum quantity of liquid to be dealt with may be decided as follows: the engineer having computed the area in acres of a district which is required to be sewered, and after investigation of all available records having satisfied himself as to the greatest amount of rainfall which may be expected, say, in one hour, may rapidly ascertain its equivalent in cubic feet per second, by utilizing the fact that 1 in. of rainfall over one acre in one hour, very nearly equals 1 cu. ft. per sec. After having made himself conversant with the geological character, general configuration and surface conditions of the area under consideration, he is to ascertain the proportion of this rainfall which is likely to reach the sewer; and this proportion of rainfall in inches per acre per hour corresponds to the same number of cubic feet per acre, per second, which will, with the addition of the sewage, be the maximum flow to be dealt with. Having prepared profiles, from which to ascertain the available gradients which will ensure that the lowest points in the district will be satisfactorily drained, and the size of the sewer that is capable of discharging at the available gradient the maximum flow when running two thirds full,

or such proportion less than full as the engineer may decide as reasonable to guard against the sewer being put under pressure. The velocity of the flow when the sewer is running two-thirds full is then to be noted, and the velocity when the minimum amount of sewage is flowing over the invert. The first result will show whether the sewer has a velocity which is too great, considering the material of which it is proposed to be constructed, and the second result whether during periods of minimum flow the sewer will be self-cleaning or not. In the latter case either the shape of the sewer or its gradient should be modified. If neither improvement can be made, flushing arrangements should be adopted, unless further consideration show that it would be advantageous to alter the general arrangement of the proposed sewerage system and substitute an improved scheme.

The partially separate system.—This system has the following advantages:

1. It is not necessary to have the sewers of enormous diameter.

2. Consequent great economy is the general result.

3. The depth of the surface water conduits need not be so great as that which is necessary for sewers.

4. The exclusion of road detritus from the foul sewers.

5. Its evident advantages where the sewage has to be pumped or purified.

6. The greatest accuracy with which the quantity of sewage may be calculated and the sizes of sewers apportioned.

7. Where old and defective sewers exist they may be used to carry surface water, although quite inappropriate as sewerage carriers.

The cost of the partially separate system is generally from one-eighth to one-half the cost of the combined system for corresponding conditions. This relates to the system of sewage conduits, but it is also evident that where the sewage has to be purified, the expense will be very materially reduced by the exclusion of the storm water. The partially separate system, if properly constructed, will meet the requirements for the efficient removal of house sewerage more perfectly, and under conditions more strictly sanitary, than the combined system. In the partially separate system the sewers, being of small capacity, will run comparatively full once every day, in dry as well as in wet weather, and this tends to prevent permanent deposits; the sewers will have uniform velocities of flow, and consequently can generally be constructed with flatter grades than in the combined system. Moreover, when flushing is necessary, the same degree of cleanliness can be obtained with less water in the partially separate system than in the combined system. This system has been found to be peculiarly adapted to the requirements of small towns. The comparative small cost of this system permits its construction in towns and suburbs where the greater expense of the combined system would render the construction of a sewerage system impracticable. The population of such districts not being dense, the question of surface drainage is not of an urgent nature. The comparative advantages of the partially separate system for large and densely populated cities, however, are not so great.

With regard to ventilation of the partially separate system, the small pipe may go right from the basement to above the roof and be open throughout as a vent to the sewer. Of course, each fixture in the house must be properly trapped and air-back-vented to prevent siphoning, and such vents should be connected with a common ventilating pipe leading to above the roof.

House drains should be constructed of stoneware pipes, salt glazed, perfectly smooth inside, of true circular section and thickness of material, straight in the direction of their lengths with whole sockets of proper depth, and free from cracks, blisters, sand holes, etc.; the internal diameter of the sewer should not be too large, 4 ins. is sufficient on an ordinary house sewer and 6 ins. is generally quite sufficient to carry off all the sewage from an extensive establishment, even if the water from the roofs or a portion of it is included. The inclination is governed by circumstances, but about 1 in 30 for a 4-in. and 1 in 60 for a 6-in. pipe is found to be a very convenient fall for many hydraulic and other reasons, and will keep a siphon clear. The joining of the pipes should be executed with great care and each pipe should be joined separately, and it should be seen that no cement is left in the drain and that the joint is good all round. Sometimes tarred gaskin is used to prevent the entrance of cement in the pipes. The sockets of the pipes should be sunk into the ground at the bottom of the trench so as to give an even bear-

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ing, which amongst other benefits dispenses with the chance of settlements. No pipes should be allowed to be covered in until they have been inspected by the town engineer or his assistants. In order to test the soundness of the joints, fill the drain with water, having first stopped up the lower end, and note if the level of the water is maintained. Stoneware pipes should be constructed to within 5 ft. of the building. Care should be exercised in filling over pipes, not to break or injure them. The trap of the house drain, where such is used (and such is in general use in the combined system), should be a siphon with a good cascade action. Its position must be determined by circumstances. I would urge the necessity of a register of all house sewers being kept that are examined by the engineer's department. This can be done by having a series of numbered notebooks kept solely for the purpose, and all the information thus acquired should also be plotted on the map of the town, if on a sufficiently large scale. The necessity of correct plans for the drainage of buildings cannot be over-estimated, especially for hospitals, asylums, workhouses, schools and other public buildings, and even for the smallest dwelling-house such a plan would often prove to be the greatest boon to the occupier or the owner as well as at all times to the city engineer, the medical health officer and the inspector of nuisances.

Underground public conveniences should be supplied in all fair-sized cities.

As a part of any sewerage system we must consider the plumbing of the houses; and any town introducing a sewerage system must adopt a plumbing by-law at the same time. Such to-day means simply a system where nothing but iron pipes are used inside the house, all of which should be exposed to view or readily uncovered. They should all be proved after being placed in position by a thorough smoke test. The soil pipe should go direct from the basement to above the roof. Each fixture must be properly trapped, air-back-vented to prevent siphoning, and such vents should be connected with a common ventilating pipe leading to above the roof. The soil pipe should be suspended from the ceiling or walls of the cellar, and have a strong iron hanger placed on it close to the stack, and where possible two hangers, one on each side of the stack, and have cleaning screws every 25 ft., along the horizontal soil pipe within the house.

SEWAGE DISPOSAL.

The following are the systems which have so far been tried and adopted in many instances:

1. Burial in the earth,
2. Discharge into the sea or tidal estuary.
3. Irrigation.
4. Precipitation.
5. Filtration.
6. Electrolysis.
7. Bacteriolysis.

Burial in the Earth.—The contents of the pails should not be buried in the subsoil, but where possible should be nearly plowed into the vegetable soil.

The Septic Tank System.—In this system purification is entirely by natural agencies, and the septic tank itself is merely a receptacle designed to favor the multiplication of micro-organisms and bring the whole of the sewage under their influence. To this end the tank is of ample size, covered so as to exclude the light, and as far as possible, air. The incoming sewage is delivered below the water level, and the outlet also is submerged, with the two-fold object of trapping out air and avoiding the disturbance of the upper part of the contents of the tanks. On entering the still water of the tank, the soils suspended in the sewage are to a great extent disengaged, going either to the bottom or to the surface, according to their specific gravity. In the absence of light and air, the organisms originally present in the sewage increase enormously and rapidly attack all the organic matter. By their action the more complex organic substances are converted into simpler compounds; and these in turn are reduced to simpler forms, the ultimate products of the decomposition in the tank being water, ammonia, carbonic acid and other gases. Other nitrogenous compounds may also be present, but they will be soluble in a slightly alkaline solution—a condition which obtains with every normal sewage.

The tank should be constructed of such a size as to hold the daily amount of sewage from the town to the sewage level in the tank with the space of about 2 ft. between the sewage level and the crown of the arched roof. The tank should have two small detritus tanks at the inlet and be provided with penstocks in order that one detritus tank may be cleaned while the other is being used. The lower part of the detritus tanks should be in two compartments, a strainer to act as a baffle for corks, etc., should be placed in the

surface of the sewage almost immediately above the division in the lower part of the detritus tank. There should also be a penstock arrangement between the detritus tanks and the septic tank in order that the septic tank and the detritus tank may be all one compartment; there should be a manhole at the inlet pipe in which one of the penstocks may be placed, one for each detritus tank and another for the septic tank itself. The septic tank should have an outlet pipe to allow gases to escape. The bottom of the tanks should be sloped to an outlet for cleansing purposes. The effluent outlet should be a pipe with a slot cut in the side or a chamber to simulate such a pipe terminating in a well outside. From the well the effluent should pass into aerating troughs, over the side of which it may fall into channels leading to distributing wells, or direct to the filters.

The capacity of the filters should be such that when filled with the filtering material, the interstices may be about able to hold the amount of sewage to be disposed of daily. The filters may be about 5 ft. deep. Collecting drains are laid in the bottom of the filters joining the main collectors, the latter terminating in discharging wells or at the filtrate outlet. The filtrant may be coke breeze, broken furnace clinkers, etc. The supply to the filters is not to be continuous flow in and out, but intermittent. Each filter is to be put through a cycle of filling, resting full, emptying and aerating or resting empty. The filters should consist of a set of five or nine, one of a set being held in reserve. Where natural sand beds can be obtained these may be used instead of the artificial filters mentioned; they may be used exactly as outlined in the following description of the disposal of sewage for rural residences.

A Septic Tank and a Sub-Irrigation System Suitable for Rural Residences.—Under this system, in suburban and rural residences where water has been introduced by windmill or force pump to a tank in the house, a simple septic tank can be installed at a very little cost, and it will provide for the decomposition of the organic wastes, without nuisance, and the regular intermittent discharges of the liquid for such a tank 3 × 3 × 3 ft., can be regulated by a valve in a chamber 3 × 2 × 3 ft.; these discharges can be led by a main sewer to a series of field tiles placed level or inverts 1 ft. beneath the surface of the ground and about 1 ft. apart, in the garden at the rear of the house, about 30 × 40 ft. rectangular. This area is usually sufficient space whereon to discharge the wastes from an ordinary house. A larger tank and more tiles in a larger piece of ground can be utilized for a number of houses. The ground must be fairly porous, the more gravel and sand the greater the capacity, but some clay loams will do duty naturally; if not they can be made to act by laying subsoil tile drains, say, 3 ft. deep. The cold of winter will not prevent the operation of the septic tank if it is banked with earth, has a double, air-tight cover, and the area holding the field tiles is covered with a good 2 or 3 ft. of straw, kept in place and not tramped down. This serves to hold the snow and so this non-conducting surface allows filtration to go on through the winter. It is apparent that what is thus available for separate houses can be enlarged into a system for a block or street, and even for a whole town, where the natural drainage areas often make it desirable to have several main sewers connected with sewage disposal systems at the ends.

SCAVENGING.

By this is generally meant:

1. The removal of house refuse;
2. The cleansing of privies;
3. The cleansing of streets.

Undoubtedly the best method for the removal of refuse is the house to house call system. For many years before the growth of sanitary science, it was thought sufficient to tip this material into pits or on to waste land, upon which houses were eventually erected; but this unwholesome practice is now being done away with. The difficulties in attempting to dispose of town refuse in an economical and sanitary manner has led to the use of what are called refuse destructors. The principal points to be aimed at with regard to the installation of these are:

1. Convenience of locality to prevent long cartage;
2. Easy access of carts to tipping platform;
3. Easy and rapid means of charging furnaces;
4. Perfect combustion with no nuisance;
5. Ease of stoking and withdrawal of clinker and ashes;
6. Reduction of material to minimum of clinker and ash;
7. Quick combustion;
8. A minimum of hand labor;

9. No stewing of the refuse on the top of furnace;

10. Securing as much thermic value as possible.

In order to meet these requirements, a number of destructors have been invented and constructed.

The cleansing of privies has been mentioned under sewage disposal.

CLEANSING OF STREETS.

There is no doubt that for the sake of the appearance, as well as the health of any town, its streets cannot be too well cleaned; this is best effected by machinery. I am of the opinion that the work of the collection of house refuse and cleansing of streets should be carried out by the local authorities with their own officers and staff, and that executing this work by contract is a mistake and a false economy. It is, perhaps, true that it may be done in the latter manner at less actual cost to the taxpayers; but all public work should be done in the best manner possible, irrespective of cost, thoroughly, but without extravagance, and the result of such work, especially when it effects the cleanliness and the appearance of a town soon fully repays any moderate extra cost that may thus have been incurred, irrespective of the enormous benefit that is conferred upon any community by the reduction of disease and the death rate by a proper attention to such necessary sanitary work.

CEMETERIES.

These should not be constructed within 200 yds. of any dwelling. The soil of cemeteries should be of a loose porous nature, with numerous close interstices through which air and moisture may pass in a finely divided state freely in every direction. They should be free from hard rock to a depth of 12 ft. and should be drained also to the depth by 9-in. glazed earthenware pipes, joints left open. On top of those there should be placed at least 3 ft. of gravel, broken stone, clinkers or some such material. One of such drains should be placed in the center of each path or road. There should be manholes as in ordinary sewerage systems at the intersection of the roads; the unaltered drainage should not be allowed to pass into any water course or stream. The graves should have a surface area of 4½ × 9 ft.; the first burial should take place at a depth of 9 ft. and the last at a depth such that the surface of the coffin will not be less than 4 ft. below the surface of the ground. No grave should be nearer the boundary line than 20 ft. Cemeteries should be properly and suitably fenced to prevent animals straying over the grounds.

COMPRESSED AIR AND THE KINETIC THEORY OF GASES

By J. H. HART

CONDENSED FROM "POWER"

To the ordinary consumer of compressed air it serves simply the purpose of an energy reservoir and for power transmission. Its utilization in this field is so efficient and is so easily obtainable that it is doubtful if it will ever be replaced by any other material. In reality, however, the general viewpoint of compressed air as an energy reservoir is fallacious—compressed air contains no more energy than ordinary air. Compressed air is simply air which has been compressed to a higher pressure and the laws which govern it are simply those which hold throughout in the kinetic theory of gases. According to this theory, a gas is made up of individual molecules flying around through space like small projectiles, colliding and re-colliding with each other and with the walls of containing vessels. The summation of this series of blows on a surface constitutes what is known as pressure. The real meaning of temperature is absolutely unknown, but it is known that absolute temperature to-day is directly proportional to the mean kinetic energy of these small projectiles or molecules. Now, in order to understand variations in pressure, temperature and volume, a complete knowledge of the relations of these projectiles to each other and the

transfer of energy between them is absolutely essential, and a study of this phenomenon is what is known as the kinetic theory of gases.

To show that the first statement in regard to compressed air as an energy reservoir is true, all we need to consider is the fact that the temperature, if not identical with, is at least proportional to, the energy of the molecule. When a gas is compressed the molecules are given an increased amount of kinetic energy. This means that they are raised in temperature by compression. If the gas now under pressure is allowed to cool off to normal temperatures it thereby loses the energy which has been put into it and which has become apparent as an increase in temperature. Each molecule possesses precisely the same kinetic energy as before compression and in a gas, unless extreme compression is accomplished, the molecules still remain at a distance sufficiently apart to have no influence on each other. Hence the total kinetic energy in the gas under compression is identical with the total kinetic energy in the gas before compression. Of course, the energy has been concentrated in amount per cubic foot, but if this gas were allowed to expand, in a cylinder without access to the outside air, or, rather, without thermal connection with surrounding bodies, little or no work could be obtained from it.

COMPRESSED AIR MERELY TRANSFORMS ENERGY.

In reality, a gas under pressure, when it starts to expand, loses some of its energy to the piston. It then possesses a smaller amount of mean kinetic energy per molecule and is, therefore, at a lower temperature. It is immediately raised by the surrounding atmosphere, or containing vessel, to normal temperature and can then continue doing work at this higher pressure, and the process continues until the pressures on both sides of the piston become equal. From this it is evident that compressed air is not a reservoir of energy in any form; it is merely a transformer of energy which has been put first into the compressed air, and lost from that into the atmosphere, from which it is taken back when it is desired to be utilized. This is a rather new conception of compressed air for most engineers, but there is no doubt at all that it is a correct statement of actual conditions. Compressed air expanded freely into a vacuum does absolutely no work and does not cool off or lose energy. In reality, the compression of air means, from the thermodynamic viewpoint, an increase in its entropy.

This becomes evident when the compression on a pressure-volume diagram is considered. Every engineer knows that the curve which represents adiabatic compression is steeper than the curve representing isothermal compression. An adiabatic curve is synonymous with what is known as an "isotropic" curve, and this latter name is quite as generally used. An isotropic line is a line of constant entropy, and going from one isotropic line in the pressure-volume diagram to another means a change in the entropy. Now most compression is adiabatic, if at all rapid. Of course, the object in compression is to get the curve as near isothermal as possible in order to diminish the amount of work necessary to produce the compression. Hence, we have three-stage compressors in which the gas is compressed adiabatically, then cooled off to the temperature that it would have had if compressed isothermally, and the process repeated twice, giving three stages. This results in an increased efficiency of production, but since the processes are identical in action only one —that of the single-stage compressor—need be considered. In this the compression is generally adiabatic, then the curve drops vertically to the isothermal point as the gas cools off and the pressure diminishes on this account without change in volume. At this point in the diagram, however, the gas has reached another adiabatic curve passing through this point so that the total change in the gas is in reality simply a change in pressure, volume and entropy, whatever the latter may mean.

KINETIC THEORY CLEARS UP COMPLEX POINTS.

There is no doubt that a capable treatment of the subject of compressed air from the standpoint of the kinetic theory of gases elucidates many complex points and renders clear much that is otherwise obscure. This conception of the energy in compressed air explains clearly the inability to utilize it in free expansion. In the transference of energy from place to place, through long pipes, this is carried on by a series of bombardments from molecule to molecule and explains the time taken in transmission and the loss of energy, or the diminution in pressure, which results when the transmission is long. It enables the engineer to understand clearly what occurs in compression and what is meant by the different kinds of compression. Thus, adiabatic compression means compression in which heat as such does not pass to or from the air or gas in the containing vessel. Every time mole-

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cules are hit by the piston they are forced to rebound and given an increased energy. This energy is not lost in adiabatic expansion to the walls of the containing vessels, but is present when the molecules collide with the piston a second time. It explains by this reasoning the manner in which the pressure rises abnormally over that in isothermal compression.

In this latter the molecules rebound from the piston with an access of energy, but this is lost by transmission to the walls of the containing vessel before they collide again; hence the pressure does not rise abnormally over what it should theoretically be. In this respect the pressure depends simply on the force with which each molecule strikes, the number of times it strikes a second, and the number of molecules which hit per square inch of surface.

When a gas is compressed more molecules are contained in a given space, hence the bombardment increases both on account of increased number of molecules striking and on account of increase in number of times of striking per second. This explanation completely satisfies and explains the behavior of a gas in its relation to pressure and volume and also explains deviation from this relation, known as Boyle's law, and does it accurately and efficiently, so that theory is completely in accord with practice. In general, the kinetic theory of gases is the only thing that completely explains the behavior of gas under all conditions and, further, it not only does this but it has foretold many phenomena previously unknown and these have been verified by experiment.

In addition, it explains many things in thermodynamics. Thus in Carnot's cycle, if a gas is expanded isothermally as far as it can be by the limitations of the machine, each molecule hits with its maximum kinetic energy and as soon as it rebounds it obtains the same from the walls of the vessel. It is reduced to the lower temperature adiabatically, that is, most efficiently. No heat is obtained from the walls of the vessel during this change and it reaches the lower temperature and pressure with minimum effort. Then in compression each molecule is hit by the piston when it possesses its lowest possible kinetic energy and the access of energy given it at this time is lost to the walls of the containing vessel before it is hit by the piston again. Hence this compression is most efficient and in the following adiabatic compression the gas is returned to its higher pressure and temperature with a minimum loss, since no heat or energy during this transformation goes into the walls of the vessel.

There is no doubt that a study of the kinetic theory of gases completely elucidates many of the obscure points (and in fact all of them) in the conception of the compression of gases, if it is investigated sufficiently. Of course this is work primarily for physicists, but engineers are daily becoming more and more interested in physical science and it is absolutely necessary today that a compressed-air engineer, or manufacturer, or even the consumer, should know enough of this development to understand the phenomena which are going on inside of the compressor. By this means reheating, and the reason for the increased efficiency obtained thereby, become simple and clear. The presence of moisture in the air and its effect on the efficiency also are easily understood.

COMPARATIVE PERFORMANCE OF STEAM AND ELECTRIC LOCOMOTIVES*

By ALBERT H. ARMSTRONG

Before considering the electric locomotive, much the simpler of the two, it is advisable to determine the general characteristics and limitations of the steam locomotive viewed from the standpoint of the electrical engineer, in order that the scope of the problem may be thoroughly understood and the lines of contrast be sharply drawn.

Without considering the reasons governing the introduction of the electric locomotives at termini and in tunnels, we find in a comparison of the characteristics of the steam and electric locomotives a contrast so marked that it shows not only the superiority of the elec-

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tric locomotive for general railway conditions, but it also suggests changes of a fundamental nature in present methods of operation now necessary with steam locomotives. And these benefits to be secured not only occur in the operation of passenger trains, but are felt to an even greater degree in the haulage of the heaviest freight trains, a field supposedly the exclusive domain of the steam locomotive.

In general, the electric locomotive must compete with the compound steam locomotive on level divisions, and the simple engine on heavy grade divisions, although the Mallet compound has lately been introduced with some success in this latter class of work.

Owing to clearances it is seldom that a steam locomotive can work at more than 90% of the theoretical full stroke, and hence the maximum tractive effort at starting with lever in the corner will not be much greater than 88% of the theoretical tractive effort available with gage pressure in the cylinders. The steam locomotive is limited as to maximum tractive effort by its engine design, and limited as to the speed at which this tractive effort is available by the capacity of the boiler to supply steam. Thus, assuming that the locomotive will give 88% of its theoretical tractive effort when starting, it is capable of providing but 80% tractive effort at a speed of 10.6 miles per hour (with the constants of the particular locomotive chosen for illustration—of the simple consolidation type), at which the boiler is giving its full output. Hence higher speeds can only be reached with a lesser cut-off and a consequent reduction in mean effective pressure and tractive effort. Locomotive engines are generally designed to give their maximum tractive effort at 90% theoretical cut-off at a point corresponding to a coefficient of adhesion of approximately 22% of the weight upon the drivers; that is, at about slipping point of steam locomotives with good rail conditions. It is immediately evident, therefore, that the tonnage rating of the locomotive on ruling grade must be so proportioned that the maximum tractive effort called for will be less than the available tractive effort of the locomotive in order to provide a small percentage, say, 10 or 15%, for possible starting under maximum grade and load conditions. In other words, as the steam locomotive is designed so that the maximum tractive effort is delivered at a point not greater than 22% of the weight upon the drivers, it is not possible to take advantage of possible abnormally good rail conditions (either natural or made abnormal by the use of sand), as the engine itself will fail to deliver any excess tractive effort thus made available with increased coefficient of adhesion.

On the other hand, the tractive effort of the electric locomotive is limited only by the adhesion between driving wheels and rail, and aside from some 15% greater adhesion possible with the uniform tractive effort provided by the electric locomotive, it is possible with this type of motive power to take momentary advantage of abnormally good rail conditions or to derive full beneat from the use of sand; indeed, tests have been taken with electric locomotives showing as high as 35% coefficient of adhesion between driving wheels and rails. This point is emphasized as with the greater tractive effort of the electric locomotive it becomes possible to give it a higher tonnage rating for the same weight upon the drivers than would be possible with steam locomotives operating over the same track profile.

A 22 × 30-in. steam locomotive of the simple type equipped with 57-in. drivers, contrasted with both an alternating-current geared and a direct-current gearless electric locomotive designed for the same tractive effort both maximum and running, but for a higher speed, brings out sharply the small speed variation with different tractive efforts delivered by the electric locomotives, this small variation being even more marked in the case of the direct-current gearless than in the case of the alternating-current geared motor working at a lower iron saturation and thus affording a more sloping speed characteristic.

The steam locomotive chosen is typical of those in general use upon our mountain-grade divisions, the tonnage rating in operation of this particular locomotive being such as to call for a tractive effort of 25,600 lbs. on average grade and 33,200 lbs. on the maximum ruling grade occurring on a certain engine division, thus leaving a margin of 6,300 lbs. above the demands of maximum tonnage on maximum ruling grade for starting the train from rest.

The maximum speed available at the different tractive efforts is a matter of boiler capacity, condition of boiler, quality of coal, and efficiency of fireman. The first of these factors, the boiler capacity, can be controlled by properly proportioning the design of the

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boiler to engine capacity, but there are three other factors which the locomotive manufacturer cannot control, and two of these factors constitute sufficient cause to warrant a considerable reduction in the theoretical rated capacity of the boiler. Such a locomotive in prime condition carefully fired with the best coal (approximating 14,000 B. T. U.), should be able to deliver full tractive effort at 10.6 miles per hour, but in practice it has been found that the average condition of boilers and the average firing provided by the none too conscientious or diligent fireman, cuts the sustained boiler output down to not much greater than 75% of its output under what must be considered exceptional or momentary conditions.

The "critical speed" of the locomotive is 7.93 miles per hour when working at 75% of full attainable boiler capacity, and the coal consumed under such circumstances will be 4,360 lbs. per hour, corresponding to 1.28 lbs. of coal burned per square foot of heating surface, at which rate we would expect an evaporation of approximately 7 lbs. of water per pound of coal.

What might be termed the "performance capacity" of a steam locomotive may be worked out from its speed and tractive effort characteristics, using as a basis the 1,000 ton-miles trailing load moved per hour on a level or any gradient selected. The prevalence of 2.2% ruling grade on many of our Western roads perhaps justifies the selection of that figure for demonstration purposes; and the coal consumed, crew wages, and maintenance charges may all be worked out from the basis of continuous operation per 1,000 ton-miles trailing load on 2.2% grade.

Having broadly outlined the performance characteristics of the simple consolidation engine frequently met with in heavy grade operation, it becomes necessary so to proportion the constants of the electric locomotive, assumed to replace it, as to gain the greatest benefit from the different inherent characteristics of the latter type of motive power.

With the small speed variation of the electric locomotive, and due to the fact that its motive power is separate from its unlimited source of power generation, it is possible to consider radical changes in the method of moving freight, more especially on mountain-grade divisions. It has become a partly accepted fact that the electric locomotive characteristic should be so proportioned as to enable it to operate trains at a high rate of speed on level track and at a much slower speed on grades, in fact, conforming with present steam practice in this respect. The writer would again point out that steam railroading to-day is in reality steam locomotive practice in that the speed possibilities of different track divisions are restricted to a large extent by the limitations of the steam locomotive. In other words, the only reason why it is common practice to run at very low speeds on mountain-grade divisions instead of continuing the high speeds in vogue on more level portions is because a steam locomotive cannot be built powerful enough to supply the heavy tractive effort required at any higher speeds than those now in vogue.

Except for the fact that curves are usually of shorter radius on heavy grades than on levels, there is no reason for the slower speed of trains, provided a type of motive power is available that is capable of supplying great draw-bar pulls at high speeds. It is just this characteristic which the electric locomotive possesses to an almost unlimited extent, and such locomotives can be built which are even more powerful and operate at higher speed than can be utilized at present.

The electric locomotive may be equipped with motors of several different types, each having characteristics best qualifying it for certain classes of work. As the direct-current gearless motor can be built in the largest sizes, is the best understood, and is in successful operation upon a very important division of one of the largest steam roads, it is here chosen as the equipment of a typical electric locomotive.

The large output, 480 HP. for one hour and 400 HP. continuously, illustrates what can be accomplished with this type of motor. The output of the complete locomotive is dependent upon the number of motors permitted with the construction adopted. Thus, such a four-motor equipment is capable of delivering a tractive effort of 56,800 lbs. at a speed of 23 miles per hour approximately (depending upon the voltage), while the efficiency of conversion at this output would be 87%, rising to a maximum of 93% at higher speeds and lower tractive effort. Another form of construction, say one similar to that employed in the largest Mallet compound, would permit the use of two four-axle articulated trucks, providing an equipment of eight motors and an output of 113,600 lbs. at a speed of 23 miles per hour.

The same motors could readily be rewound

to give the same tractive effort at considerably increased speeds if desired, without materially increasing the internal losses of conversion. Bearing fully in mind the fact that a single operator has this enormous energy under perfect control, and that such a locomotive could do the work of two or more Mallet compounds and several locomotives of the simple Consolidation type, it becomes evident that in the electric locomotive there are tremendous possibilities of improving present methods of railway operation as now conducted with the steam locomotive. Carrying the thought a step further and appreciating that several such electric locomotive units may be operated in a group forming a combined unit, it becomes evident that in the electric locomotive we have a type of motive power capable of furnishing any output in tractive effort and speed that present or future operating conditions may demand.

Though the electric locomotive can very readily be designed to give the same tractive effort at a higher speed, 30 miles per hour is assumed as the highest speed permissible due to the alinement of the track on heavy grades.

To plot a performance capacity curve for the electric locomotive, certain further assumptions are necessary.

Type of equipment, direct-current gearless motors.

Weight of total locomotive	125 tons.
Weight on drivers	100 "
Engineer, wages per hour	$0.50
Conductor, wages per hour	0.40
Three brakemen, wages per hour	0.90
Total wages of crew	1.80

Efficiency of transmission, rail to bus-bar, 70%.

Maintenance of locomotive, 5 cents per mile run.

The train crew is so divided as to permit the location of a brakeman in the engineer's operating cab.

The cost of electrical power must in this instance be most arbitrarily assumed, owing to the widely different cost of coal, possibility of water power, etc., obtaining in different localities. As the cost of coal for steam locomotives will also vary greatly as to price and quality, it has been assumed at $3.00 per 2,000 lbs., and a cost for electric power of one-half cent per kilowatt-hour is based upon using the same price and quality of coal. As it is further assumed that an entire engine division of, say, 150 miles is to be electrified, it gives promise of a 24-hour load-factor of 50%, and this figure has been taken. Approximating the first cost of installation of the generating station at $100.00 per kilowatt, and allowing 10% per year for interest and other fixed charges, the cost of power is brought up to possibly $0.0075 per kilowatt-hour at the station bus-bar.

The reduction in the operating expenses is effected in the two items of crew wages and maintenance of locomotives, and the cost of fuel remains practically unchanged. The speed does not affect the cost of fuel or power, it being assumed that the motive power for the various speeds is so proportioned as to operate at the point of greatest economy.

With coal at $3.00 per 2,000 lbs. in each case, the steam locomotive can generate a horse-power at the drivers at an expenditure of $0.006, as against $0.0039 for fuel alone with the electric; but the two figures are not directly comparable.

The saving or deficit in the power item with electric, as contrasted with the fuel item of steam locomotive operation, must be largely determined by the local factors entering into the case.

The cost of fuel or power, being fundamental, constitutes a fixed item in the total cost of operation, while the other two items, crew wages and maintenance expenses, will be determined solely by the method of operation and the excellence of motive power used.

The schedule speed on several mountain divisions is approximately 50% of the average running speed, and this figure is assumed in the following statement of cost of operating 1,000 ton-miles with steam locomotives, averaging the cost of up and down-grade running. Owing to the higher schedule speed of electrically operated trains, resulting in fewer meeting points with the same tonnage handled, and due to the absence of forced stops to take on fuel and water, etc., it is assumed that with electric motive power the schedule speed may be 60% of the running speed.

With the electric locomotive standing, or coasting down grade, there is no demand whatever made upon the generating station, and hence the only expense carried through these periods is that for train crew and a certain amount for maintenance. On the other hand, with the steam locomotive there is a considerable amount of fuel burned and water wasted when standing at sidings and when coasting. In the case of mountain railroading, with its frequent and prolonged delays,

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this waste may reach considerable proportions.

Locomotive performance capacity curves may therefore be plotted which will show approximately the true relation between the several items of fuel, crew wages and motive power maintenance, by adhering to the following assumptions:

Ratio schedule to running speed up-grade, steam locomotive.....50%
Ratio schedule to running speed up-grade, electric locomotive.....90%
Schedule speed down-grade, steam...15 mi. per hr.
Schedule speed down-grade, electric..18 mi. per hr.
Cost of coal.....$3.00 per 2,000 lbs.
Cost of electric power.....$0.0075 per KW.-hr.
Efficiency of distribution.....70%
Crew wages per hour, steam.....$2.15.
Crew wages per hour, electric.....$1.80.
Maintenance locomotive, steam.....$0.137 per mile.
Maintenance locomotive, electric....$0.05 per mile.
Fuel waste per idle hour, steam.....400 lbs.

In practical operation the fuel expense approaches more nearly to the value of the other items considered, instead of being greatly in excess of them as indicated in theoretical performance curves, showing up-grade operation only. For operation on lesser grades than 2.2% all items are reduced, and the total and sub-divided comparative costs are given in the following table:

COMPARATIVE OPERATING EXPENSES PER 1,000 TON-MILES STEAM (SIMPLE) AND ELECTRIC LOCOMOTIVES.

AVERAGE OF UP AND DOWN-GRADE OPERATION.

Steam Locomotives.

Grade	½%	1%	1½%	2%
Coal	15 cts.	25.5 cts.	38 cts.	53 cts.
Crew	13.5 "	24 "	36 "	50 "
Maintenance.	10.5 "	17.8 "	26 "	36 "
Total	39 "	67.3 "	100 "	139 "

Electric Locomotives.

Grade	½%	1%	1½%	2%
Power	20 cts.	35.5 cts.	50.5 cts.	66 cts.
Crew	7.2 "	12.2 "	18 "	24 "
Maintenance.	3.6 "	6.2 "	9.0 "	11.9 "
Total	30.8 "	53.9 "	77.5 "	101.9 "

Saving Effected by Electric Operation.

Grade	½%	1%	1½%	2%
	8.2 cts.	13.4 cts.	22.5 cts.	37.1 cts.

A study of the above table is most instructive, as it shows that while the percentage saving with electric operation is approximately the same whatever the ruling grade, yet the actual money saving is much greater on the heaviest grades. As about the same investment must be made in each case for distribution system, including third-rail or overhead trolley, sub-stations, etc., the inference must be drawn that heavy-grade divisions present a more attractive field for electrification than level sections when considered from the purely economic standpoint. There are other items of saving and other reasons for electrification which may be more or less controlling in individual cases, but it seems possible to make the broad statement that the mountain-grade division offers a particularly attractive field for the electric locomotive, and its introduction should be the means of effecting such economies in both freight and passenger transportation as to pay a satisfactory return upon the investment required.

So far, the matter has been viewed from the standpoint of comparative operating expenses for a given tonnage moved. There is another argument for electrification which may, in certain instances, be of a much more controlling nature. Most of our mountain roads are single track, and trans-Continental tonnage has so increased as seriously to congest these mountain divisions. The heavy trains of the plains, weighing 2,000 to 3,000 tons, must be split up into units of about 1,000 tons, in order that the present steam engines, operating double and even triple, may haul them over the heaviest grades. The slow speed obtainable makes the number of trains on a mountain division large, the meeting points frequent and hence, however good the dispatching system employed, there will of necessity be a considerable amount of lost time. Add to this the failures of motive power being worked to its limit, and there is reason for the claim that the tonnage capacity of the division will be greatly increased by the introduction of electrically-hauled trains.

The latest Mallet compound, weighing 413,000 lbs., is the largest steam locomotive yet built, and is of particular interest owing to the enormous boiler which such a construction permits. With a total heating surface of 5,300 sq. ft. we should expect an evaporation of 63,600 lbs. of water for a short period, and possibly 48,000 lbs. water continuously. With a possible evaporation of 6 lbs. of water per lb. of coal, this would necessitate the burning of 8,000 lbs. of coal per hour, requiring the best efforts of two firemen if maintained for several hours. Assuming a steam consumption of 22 lbs. per B. HP.-hr., such a locomotive should give a sustained output of 2,180 HP. at the rim of the drivers, and this with a weight with tender of approximately 300 tons, or three times the weight of an electric locomotive of the New York Central 6,000 type giving the same horse-power output.

The two locomotives are, of course, designed for entirely dissimilar classes of work; but it is not unfair to compare them on a horse-power basis as it is the huge boiler of the Mallet that is remarkable, and upon this basis the selling price of the two machines is approximately the same.

The comparative cost of electric and steam

locomotives is generally considered as very favorable to the steam units, but reversing the usual methods and comparing the cost of the electric with that of the steam locomotive or locomotives required to replace it, may reverse the relations. The electric locomotive requires no more than casual inspection, can be side-tracked indefinitely and still be ready for instant operation at full capacity, can run 24 hours without a stop, if necessary, and all these advantages and others offer a guarantee for a much greater annual mileage than is possible with its steam competitor. Then, too, compare the cost of a group of steam locomotives (no single unit could be designed to give the output) capable of delivering even 4,000 HP. continuously, with a single electric unit of this output, and the difference in cost is not great. It may be stated broadly that for a given gross annual ton-mileage moved, the cost of steam locomotives may be even greater than the cost of the electric units replacing them.

As against the reduction in fuel expenses promised by the use of the compound locomotive fitted with superheaters and feed-water heaters, the electrical engineer has up his sleeve the great possibilities offered by regeneration of power while electrically braking on mountain-grade divisions. The amount of power saved by this means may in certain installations amount to as great a percentage of the total as is the saving effected in coal expenditure with steam locomotive by compounding and providing superheaters and feed-water heaters.

The chief advantage of regeneration lies in the assurance it offers of greater safety in operating on heavy grades. The present method of braking, by friction between wheel and shoe, results in overheated parts, breakages resulting therefrom and consequent danger of derailment. The descent of a long heavy mountain grade is accompanied by the shoes and wheel rims becoming heated to a dull red, while the introduction of the electric locomotive offers an opportunity of holding the train in whole or in part by means of the same motors used to haul it up grade, and thus eliminating one of the greatest sources of danger in mountain railroading.

The subject of the electrification of steam roads is a very broad one, and while this paper has been devoted largely to a discussion of operating expenses as affected by the different characteristics of the two types of locomotives, it has been done to illustrate the advantages resulting from increased locomotive capacity. The keynote of electrification is capacity; by approaching the problem from this standpoint only can full benefits be obtained.

DIRECT AND INDIRECT METHODS OF ELECTRICAL PURIFICATION OF WATER

By HENRY LEFFMANN

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It is about a century since the results of electrolysis began to attract attention, but the commercial exploitation of the processes was impossible until the economic production of the processes practical. So far as the purification of water is concerned, but little result was expected from electrolytic methods until the discovery of the microbic life in water and its relation to disease. The latter discovery was promptly made the basis of a rapid and brilliant, but in some respects untrustworthy, development. Water analysts, and sanitarians generally, were often misled by the statements emanating from bacteriologic laboratories. Even to-day we must receive with caution publications from such sources, especially tabulated results of experiments.

It is not necessary to review the history of the application of electrical currents to water purification, nor to describe even briefly the numerous patents that have been granted for such purposes. I propose to refer here only to some that have come under my own observation, in consequence of having been asked to make expert investigations. Some attempts have been made to remove the mineral impuri-

ties from water by taking advantage of the electrolytic powers, but most processes have been intended to kill the microbes. The ordinary inventor has proceeded upon his (generally superficial) knowledge that the disease-carrying power of water is dependent upon bacteria, and that electricity in sufficient strength is fatal to living matter.

In some of the processes the method has been the crude one of simply passing electric discharges through the water, hoping to kill the bacteria by direct shock. Thus, in one patent which was submitted to my consideration a few years ago, the inventor proposes to have electrodes passed into the water-main through insulated sockets and discharge a succession of sparks across the stream. The impracticability of the method, on anything but the most minute scale, seems not to have appeared to him.

I have seen in operation several methods of water purification by means of electrolysis. In these aluminum electrodes have been used, and more or less loss of the metal has occurred, it being converted into aluminum hydroxide. This produces its usual effect, that of combining with the organic matter and entangling the suspended substances, so that the water, after treatment, can be subjected to a rapid filtration, and will show material improvement in microbic content, especially if the amount of suspended matter and microbic content were previously high. On waters containing but little suspended impurity, living or dead, the purifying action is relatively low. The constant loss of the electrode is, of course, a most serious item of expense, generally overlooked in the experimental plants.

In the operation of the Anderson process of purifying water by agitation with metallic iron, attempts have been made to get more powerful action—that is, more rapid solution of the iron—by making it the positive pole of an electric system, but no practical advantage seems to have been attained. Recently, a process has been patented in which an electric current is passed from an inner to an outer pipe, the water flowing through the annulus, but I have no practical knowledge of this method.

It seems to me that the most practical benefit of the application of electricity to water purification will come from the indirect methods in which the electrical energy is used to produce an active disinfecting agent, and this then applied to the water. Of all the processes of this type, those which produce ozone seem to be most useful. The material from which ozone is obtained—air—is in unlimited supply, and the addition to water cannot be regarded as being dangerous, since if present in excess it soon reverts to the condition of ordinary oxygen.

The principal problem in this method is the economic production of ozone. This modification of oxygen can be obtained by several methods of different types, but those in which electricity is employed seem to be alone applicable to the processes in question here. For the purpose high-tension currents are most economical, and the best yield is obtained by the so-called "silent discharge." It is now known that a spark or arc discharge will produce nitrogen oxides which are corrosive. It has also been determined that the air intended for production of ozone should be dry, otherwise hydrogen dioxide will be formed. The principal mechanical difficulty encountered in producing ozone on the larger scale by means of the electric discharge is to secure a suitable dielectric. Glass, porcelain, rubber, and other materials have been tried, but are so liable to fracture or perforation that serious interruptions of operation frequently occur. Continuity of action is very important in commercial processes, such as the purification of water, and when a large unit of the plant is out of use in order to install a new dielectric, the condition is annoying.

The inventions of Vosmaer seem to overcome the difficulty, for he avoids the use of a special dielectric, employing only the dry air which is to be ozonized. The discharge takes place from thin metal strips, on which are saw-like teeth. These strips are held by insulating (porcelain) sockets firmly in the center of metal pipes. Many of these pipes are combined in parallel, the strips being all connected with one pole, and the pipes with the other. An alternating current of high potential is allowed to flow through the arrangement, almost all the current passing by silent discharge, although at times a spark passes, but as there is no permanent dielectric no damage is done. The sparking is too seldom to produce damage or any appreciable amount of objectionable gases. The drying of the air may be done by any of the known methods. Preference is given by Vosmaer to refrigeration, by means of an ordinary ice machine.

A plant capable of purifying many thousand gallons in 24 hours has been for some time in operation on the west bank of the Schuylkill

River at the foot of Locust St., Philadelphia. The water is first roughly filtered. This operation is merely intended to remove the grosser suspended matter, as the ozone process proper does not accomplish this. As the main part of the operation is the destructive action of the ozone on the bacteria, it is not necessary for the preliminary filtration to be nearly so close as when the latter is the sole reliance (as in ordinary filter plants), hence the filter area in the ozone plant is relatively very much smaller, the rate of filtration being so much greater. The filtered, or, perhaps, we may call it strained water, is passed into aerating towers. These are tall, narrow vessels, into which the water enters at the top and the ozonized air at the bottom, the latter under considerable pressure. In the experimental plant above mentioned, an exhibition mixing tower has been installed. This is a glass tube about 16 ft. high and 10 ins. in diameter. In this the admixture of the ozone current with the water current is well seen. Upon the thoroughness of this mixing depends, in large part, the thoroughness of the purification. The water escapes at the foot of the mixing tower, clear and practically sterile. It sometimes contains a small amount of ozone in solution, but this is not objectionable and soon disappears, either by conversion into ordinary oxygen or by combination.

The advantages of the process may be summarized as follows: no objectional chemical is introduced into the water; large filter beds are not required; the operation expenses are not high; the plant occupies a limited area and the operation is simple and easily comprehended; the plant may be enlarged by the addition of new units without disturbing the original units; the sterilization is rapid and certain; the plant may be placed at any convenient point. The process seems to me to find even more valuable application to the purification of sewage than to ordinary water supply. Both of these problems are now among the most urgent questions of sanitation.

The extensive use of water in our domestic life, with the increasing sources of pollution, give importance to every method of purification, and processes that seem to be founded on scientific principles and seem capable of practical operation on a large scale, and to involve low operative cost, limited land area and freedom from dangerous chemicals deserve careful investigation. Many tests of the bactericidal efficiency of the plant were made. Some made by myself showed that the water as discharged from the ozonizer is practically sterile.

PRACTICAL ENGINEERING IMPORTANCE OF STEFAN AND BOLTZMANN'S RADIATION LAW

In a forthcoming bulletin entitled "Study of Four Hundred Boiler Tests, with Deductions," the steam engineering division of the United States Geological Survey treats of the lately-developed and proven law of Stefan and Boltzmann regarding the total radiation of heat (including light) from a hot to a cold body. It was formerly thought that the amount of heat radiated was proportional to the temperature difference. Inasmuch as former experimental work was done at low temperatures, the error of this assumption was very small. But of late years, since interest has arisen in the quantitative investigation of high-temperature furnaces, it has become important to think with the true law in mind. This law of Stefan and Boltzmann states that if two infinite plane surfaces are close together, or, better still, if a ball is inside a hollow sphere, both surfaces being in all cases of the same material in the same state of surface finish, this law states that the rate of heat radiation from the hotter to the cooler surface is

$$\text{Rate of radiation} = K\ (T_1^4 - T_2^4),$$

where

K = a constant for any particular set of bodies and surfaces.

T_1 = the absolute temperature of the hotter body.

T_2 = the absolute temperature of the colder body.

The above equation is equivalent to stating that each body radiates heat and receives

heat by radiation; that the rate of radiation from each body is proportional to the fourth power of its absolute temperature; and therefore that the net amount of heat given up by the hotter body to the cooler one is proportional to the difference of the fourth powers of their absolute temperatures.

The above-mentioned forthcoming bulletin, giving a "Study of Four Hundred Boiler Tests, with Deductions," makes a number of applications of this law. Some similar applications are given below.

Examples.—In a Heine water-tube boiler having the lower row of tubes over the furnace completely encased in clay tiles, excepting about 3 ft. at the rear end, over the combustion-chamber, this exposed 3 ft. of tubes absorbs heat not only from convectional contact with the gases entering the boiler, but also from the intense radiation from the white-hot combustion-chamber walls and bottom.

The soot covering of the water-tubes is of a different surface and finish from the surface of brick and slag constituting the combustion-chamber walls and bottom; nevertheless, the above equation will hold approximately, and some examples are given to show the enormous increase of this radiation factor with rise of combustion-chamber temperature.

Example 1.—Let the soot on the exterior of the water-tubes have an average temperature of 1,239° F.—a dull red heat. Adding 461° F. to get the absolute temperature, we have

$$T_2 = 1,700°.$$

Assume the rear furnace temperature to be 2,039° F.—a rather poor condition of operation; adding 461° to 2,039°, we have

$$T_1 = 2,500°.$$

Then, net heat received by tubes per second from furnace bottom and sides $= K\ (T_1^4 - T_2^4) = K\ (2,500^4 - 1,700^4) = K\ (30,710,400,000,000)$.

Example 2.—Let the average soot temperature be 1,239° F., or 1,700° F. absolute, as before. Then

$$T_2 = 1,700°.$$

Assume that the average rear combustion-chamber temperature is only 500° higher than in Example 1—that is, 2,539° F., a medium temperature—then

$$T_1 = 3,000°.$$

Then, net heat received by tubes per second from furnace bottom and sides $= K\ (3,000^4 - 1,700^4) = K\ (72,647,900,000,000)$.

Example 3.—Assume, as before, $T_2 = 1,700°$ F. absolute, and raise the furnace temperature another 500° F. to 3,039°, which would be wall temperature in quite a hot furnace. Therefore,

$$T_1 = 3,500°.$$

Then, net heat received by tubes, etc., $= K\ (3,500^4 - 1,700^4) = K\ (141,710,400,000,000)$.

Summary of Examples.—Dropping the constant K and the last twelve figures of every answer, we have

Furnace Temperature. Degs. Fahr.	Tube Temperature. Degs. Fahr.	Number to which Net Radiation is Proportional.
2,039	1,239	31
2,539	1,239	73
3,039	1,239	142

The heat absorbed from radiation practically doubles with every 500° increase in combustion-chamber temperature.

As a matter of fact, the temperature of the soot on the tubes rises a little as the furnace-wall temperature rises, and it is also a better radiator of heat than is the brick wall. Nevertheless, the above examples are substantially correct.

Numerical Percentages.—The above calculations give no idea as to whether the percentage of heat received by a boiler from radiation is the larger or smaller portion of the whole. In the "Study" mentioned some numerical calculations are given, determined by two independent methods of approach. The results are probably right within 20%.

It is evident in the case of an ordinary multitubular boiler, burning smokeless coal right under the boiler-shell, that perhaps half of the heat enters the water from a radiation source. Even in water-tube boilers it may be about 20%. In locomotive boilers the fire-box may sometimes absorb perhaps 30 to 50% of the total heat absorbed, most of this 30 to 50% being due to radiation.

Miscellaneous Applications of the Radiation Law.—The engineers of the steam engineering division were recently much surprised at the magnitude of thermometric errors due to radiation when measuring the temperature of dry gases. If the bulb of a thermometer had a chance to "look out-doors" when in a hot chamber surrounded by a flowing stream of hot gas, it may read twenty or thirty degrees low at the moderate temperatures of 500° or 600° F.; nor does the "window" have to constitute a very large percentage of the chamber walls in which the bulb is situated. Two thermometers a little over an inch apart in the same long chamber, swept by the same stream

of hot air, were found to read nearly 100° apart; a third one further along, carefully closed in, read nearly as high as the first one. All the instruments were carefully calibrated and were repeatedly interchanged.

In superheated-steam work such errors are very persistent. It is no easy matter to get the temperature of a flowing stream of superheated steam within 10° of the true temperature. It may be said that under such circumstances the thermometer bulbs are always colder than the steam; the only question is, How much? This fact alone will explain many troubles engineers have had in working with superheated steam and other permanent gases.

In determining the temperature of flue gases in boiler practice the errors due to radiation of heat from the thermometer bulb are usually large. Unless the bulb is carefully protected from radiation by two or three concentric chambers around it, it is likely to read dozens of degrees low. A moment's reflection will make it evident that all surfaces ordinarily "visible" to the thermometer bulb are hundreds of degrees colder than the gases (and than the bulb). This is true of the brickwork, the adjacent water-tubes and steam-drums, the stack, and the sky above.

The measurement of the temperature of a permanent gas is a high art.

CALCULATIONS FOR PLUNGER ELECTRO-MAGNETS

In order to calculate accurately the pull due to a plunger-electromagnet or an iron-clad solenoid at various points throughout the entire range, it is important to know the solenoid effect, or the pull due to the magnetizing force of the winding and the magnetic induction in the core or plunger for various relative positions. The pull due to a plunger-electromagnet may then be found for all points within the range of the magnet by adding the pulls due to the induction between the plunger and the stop, to the pulls due to the solenoid effect.

In a recent issue of the "Electrical World" Mr. Charles R. Underhill gives formulas for the calculation of solenoids, based upon the results of numerous experiments made by him. We give herewith an abstract of his conclusions:

$$IN = 98LP + (12{,}000/L),$$

where IN = the number of ampere-turns of the solenoid,

L = the length of the winding of the solenoid in inches,

P = the maximum pull in pounds exerted by the solenoid on the plunger.

This formula is for a plunger of 1 sq. in. in cross-section, above saturation. In order to determine the cross-sectional area A of any other plunger to give the proper value for IN_s with any assumed total number of ampere-turns IN, use may be made of the formula

$$A = \sqrt{(IN/IN_s)}.$$

Values for IN_s should always be assumed as above saturation and not less than

7,000	ampere-turns	for a	6-in.	solenoid,
6,000	"	"	9 "	"
5,000	"	"	12 "	"
4,000	"	"	18 "	"

Applying the formulas to a specific case—a solenoid 12 ins. long, to have a maximum pull of 30 lbs., we have, assuming $IN_s = 8{,}000$,

$$IN = 98LP + (12{,}000\ L) = (98 \times 12 \times 30) + (12{,}000/12) = 36{,}280.$$

$$A = \sqrt{(36{,}280\ 8{,}000)} = 2.13 \text{ sq. ins.}$$

Instead of using 36,280 ampere-turns and a plunger 1 sq. in. in cross-section, it will be seen that only (2.13 × 8,000 =) 17,100 ampere-turns will be required for the same pull, provided that a plunger of 2.13 sq. ins. cross-section is used.

The pull exerted on the plunger at any point throughout the range of the solenoid may be calculated from the formula

$$p = P \sin (138.6\ L_1/L) \text{ degrees},$$

where p = pull in pounds at the point in question,

P = maximum pull in pounds,

L_1 = distance in inches plunger has entered the coil,

L = length of coil in inches.

Pulls for various values of L_1 may be worked out and a curve plotted which will show the pull exerted at the various positions of the plunger.

GRAVITATION, COHESION, ADHESION:

A THEORY TO ACCOUNT FOR THEIR IDENTITY

By EDWARD GODFREY*

There seem to be two ways of "proving" that cohesion and adhesion are not identical with gravitation, and these ways are directly opposite. One says that the attraction of gravitation is not great enough to account for the force of cohesion, and therefore the attraction of elementary particles of matter at close range must vary inversely as some higher power than the square of the distance. One writer, taking quite a different view, goes to the extent of inventing a repulsive force between particles lying close to each other; for, he argues, when they touch, the attraction would be infinite. The absurdity of this last statement is made plain by the simplest kind of mathematical reasoning. The distance between two attracting bodies (which measures their force of attraction) is the distance between their centers of gravity. It is impossible for the centers of gravity of two solid spheres, for example, to occupy the same position. Hence they could not "touch," and the attraction cannot even theoretically be infinite.

It is true that there are solids that can be imagined or constructed that have their centers of gravity, as ordinarily understood, outside of themselves and in such positions that two of them could be placed with their centers of gravity coincident. This would appear to be a case where the attraction is infinite. But we know that two such bodies can be made and placed with these so-called centers of gravity coincident and yet the force of gravity between them will be altogether too minute to be measured. One of two conclusions must follow: either the law of gravitation fails in such cases, or what we have been taught to call the center of gravity of a figure is not its true center of gravity.

It can be shown that no figure except a homogeneous sphere, or one composed of homogeneous spherical shells, or a spherical shell of uniform density has a fixed center of gravity: or, more properly, it cannot be shown that any figure except those mentioned has a fixed center of gravity. Even in the case of the spherical shell it is well known that the center of gravity vanishes when the attracting body is inside of the shell; for the attraction which the shell exerts on the body situated anywhere within is nil, or more properly, is equal in any two opposite directions.

If gravitation acted with equal force on all parts of a body, the center of gravity, or the point where the resultant of all of the forces on the several particles may be considered as acting, would be the point that we commonly understand as the center of gravity. For the attraction of the earth upon bodies upon its surface this is practically true, but for the attraction of bodies on its surface for each other it is far from true. Hence the error in finding the center of gravity of a mountain in the ordinary way in the problem of determining the mass of the earth.

Sir Isaac Newton proved that two spheres of uniform density or composed of concentric shells, each uniform in density, attracting each other in accordance with the law of gravitation as formulated by him (namely, a force which varies directly as the product of the masses of the two bodies and inversely as the square of the distance between them) will act toward each other as though their masses were concentrated at their respective centers. He also proved that a body within a spherical shell will be in equilibrium so far as its attraction to the shell is concerned. Hence a spherical shell cannot be said to have any center of gravity with respect to bodies inside of the shell.

Assuming the atom to be spherical in shape, we may investigate the intensity of the attraction of gravitation as follows: Imagine two spheres of unity mass and unity distance center to center. The attraction between these spheres we will call unity. Now conceive these spheres added to indefinitely in a straight line in both directions. Each added pair will augment the attraction on this line, the respective increments being

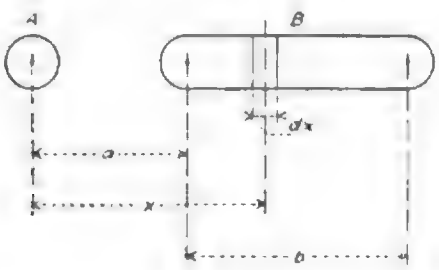
$$(1/4 + 1/4 + 1/9),$$
$$(1/9 + 1/9 + 1/16 + 1/16 + 1/25),$$

etc.

The increment is a constantly diminishing fraction of the original attraction of the two spheres, so that for a finite number of spheres

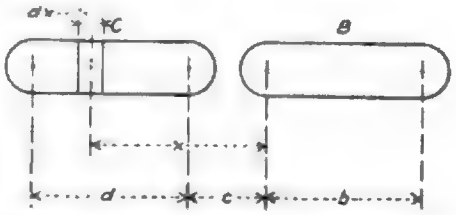
*Monongahela Bank Building, Pittsburg, Pa.

the attraction will not be many times the attraction of the two original spheres. That is, their attraction would only be largely increased by considering the mass of the two lines of spheres extending away from the original pair as very great. This would not be necessary in investigating the attraction in a "fiber" of matter. The attraction drawing these two lines of spheres together may be called M per unit of the cross-section of the fiber, or a circle whose diameter is equal to that of the spheres. Now, if the diameter of the two original spheres be considered as one-half as great, the mass of each will be one-eighth as much, and the product of the masses will be $^1/_{64}$ as great. But the reduced diameter will allow the spheres to be placed one-half of the original distance apart, making the attraction four times as great, or $^1/_{16}$ of the original attraction. But this force distributed over a surface one-fourth as large as the original would be $^4/_{16}$ or one-quarter as great in intensity per unit of sectional area. Continuing this subdivision it is seen that the value of the attraction per unit of area is immensely diminished as small spheres are considered. It is plain, therefore, that the attraction of gravitation will not hold minute spheres together with a force that approaches the cohesion between the particles of matter as abundantly exhibited. The foregoing doubtless furnishes the basis for the theory that particles at close range must attract each other with a force varying inversely as some higher power of the distance than the square. It is hard to see why such a force should exist between small particles and fail between large masses. In fact, the law of gravitation as formulated by Newton will account for the force that holds the molecules of matter together to the intensity of 350,000 lbs. per sq. in., as exhibited in steel music wire, or more than this, if any material is stronger; but not on the basis of a spherical shape for atoms.



Let A be a particle of matter conceived as a unit with attraction unity for a like particle at a distance of unity. The element of its attraction for the elongated body B, whose mass is assumed to be unity per unit of length is $\frac{dx}{x^2}$

Integrating this between the limits a and (a + b) we have $\frac{b}{a^2 + ab}$ as the total attraction of A for B.



Now consider the attraction between two elongated bodies B and C, each having a mass of unity per unit of length. From the foregoing the element of the attraction of B for C is found (by substituting x for a) to be

$$\frac{bdx}{x^2 + bx}$$

The integral of this is

$$\log. x - \log. (b + x)$$

Evaluating this between the limits of c and (c + d) we have

$$\log. \frac{(b + c)\ (c + d)}{c\ (b + c + d)}$$

if b = d, this reduces to

$$\log. \frac{(c + d)^2}{c\ (2d + c)}$$

By inspection of this expression for the attraction of two elongated bodies for each other it is seen that it increases in value as c becomes small in comparison with d. It will also be found that the centers of gravity of these two bodies are not at the centers of their length (with respect to their attraction for each other), and that these centers of gravity have no fixed location in the several bodies.

As an example, if d = 100 c, the attraction by the above is

$$\log. 50.75 = 3.93.$$

If the centers of gravity were in the middle of the lengths of these bodies, the attraction would be

$$\frac{d^2}{(1.01d)^2} = 0.98.$$

For d = 1.000 c the attraction is

$$\log. 500.7 = 6.216.$$

Or supposing the centers of gravity at the middle of lengths the attraction would be

$$\frac{d^2}{(1.001d)^2} = 0.999.$$

In the former case the apparent attraction by the ordinary rule works out about one-fourth as great as it should, and in the latter about one-sixth. It is thus seen that these two elongated threads of matter have no fixed centers of gravity with respect to their attraction for each other. It is also seen that by imagining the indivisible particle of matter a slender thread many millions of times as long as its diameter, the attraction may be conceived as any desired amount.

A theory that would account for the attraction between bodies composed thus of atoms extremely attenuated in shape is this:

The whole of space is filled with a medium which, instead of being at rest, is moving in every direction at the speed of light or 186,000 miles a second. This impinging on the atoms, if it struck with equal force on the opposite sides, would not tend to cause motion; but, if there were a void on one side of the atom, the force on the other side would give rise to the attraction that we observe between two bodies. The void is the result of the medium striking against the opposite sides of two atoms and reflecting.

This theory would fail entirely if atoms be considered as spherical in shape or if a so-called solid were really opaque; for the attraction between hollow spheres would be just as great as between solid ones. But the foregoing calculations would show that the atoms are so extremely thin that billions of billions of them in a solid body would offer but slight resistance to the passage through the body of this rapidly moving medium or the ether.

The law of gravitation which makes the attraction directly as the product of the mass and inversely as the square of the distance would be satisfied by this theory because of the practical transparency of all matter to the passage of this medium. Each atom would offer its share of resistance to this moving ether in proportion to its length, the portion covered by intersections with other atoms being infinitesimal and thus too small to make any measurable difference in the attraction, except in very large masses. The apparent high density of the earth may be due to exceptional resistance met with in the passage of the ether through so large a mass.

Light, then, instead of being wave motion in a stationary medium, in which case it ought to spread like sound, would be vibratory motion of the particles of a rapidly moving medium. An opaque body is one in which the molecules are so indiscriminately arranged that they stop to some extent the vibrations of these moving particles but do not stop more than a minute portion of them in their motion. A transparent body is one in which the molecules are arranged in some geometric order so that they do not greatly interfere with the vibrations in the ether.

Polarized light is that in which the light vibrations in the ether have been stopped in one direction (normal to the ray) but still continue in the other rectangular direction.

Only a small portion of the scale of vibrations manifests itself in light and heat, and this portion is commonly held to represent the actual energy of a ray; but may it not be true that an invisible and imperceptible flood of this moving ether contains a vast amount of energy which only a body of great thickness will "strain" out of it, turning it into sensible heat or light? This would account for the interior heat of the earth, the hotness of Jupiter, and the inexhaustible heat of the sun.

May not the molecules of radium be of such length that the amplitude of their vibration is a multiple of that of some low or high imperceptible vibration of the ether which these molecules transform into vibrations which can be seen and felt?

The theory of the conservation of energy has received a jolt in the manifestations of radium. That theory may be absolutely true, but not all energy can be measured in man's scales as yet devised; and the means of trapping the portion that cannot be perceived or measured are limited.

THE SECOND INTERNATIONAL AERONAUTIC RACE*

When Lieut. Frank P. Lahm, U. S. A., won the first international balloon race, the trophy offered by Mr. James Gordon Bennett was brought to this country to be defended by the Aero Club of America.

Lieut. Lahm traveled from Paris to the North of England, a distance of some 402 miles, and his victory over the foreign competitors was due to a greater knowledge and better judgment of the altitudes at which he might utilize the most favorable air currents. St. Louis was selected as the most suitable place in America for this year's race, and it was expected that some new long-distance and time records would be established, although the contest was to be entirely for distance. Six balloons were brought over from Europe to compete for the Bennett trophy. Of these three came from Germany, two from France and one from England. Three American balloons were entered. The capacity limit of the balloons entered was placed at 75,000 cu. ft., with an excess allowance of 5%, making a gross allowance of about 80,000 cu. ft. available. Each of the balloons entered was close to the limit, ranging from 75,000 to 79,500 cu. ft. capacity. It is interesting to note that although motor-driven balloons were allowed to compete, none were entered, and all the operators depended on their skill in utilizing the prevalent air currents to reach their destinations—wherever those might be.

Maps and all available information were placed at the foreign competitors' disposal that they might acquaint themselves with the general course of air currents in the United States and especially in the region of St. Louis. Under such conditions the pilots should have competed on nearly equal terms in this regard. In the basket of each balloon were only two persons, the pilot and one assistant. It was necessary that these men should be well protected against the cold of the season and altitudes to be reached, as no fire of any sort could be allowed on account of the gas in the bag. Each balloon carried provisions and several instruments, such as a compass, registering aneroid barometer, statiscope (to indicate the rise and fall of the balloon), thermometers, besides charts and small electric flash-lamps for reading the instruments and charts at night. The baskets were equipped with cork in one way or another so that they might float in case a balloon should drop into water. It should be remarked that no accident of this kind occurred to any competing balloon, nor did any pilot find it necessary to throw his instruments overboard or to cut loose the car, as he was allowed to do under governing rules.

The balloons were first reported as having drifted around at different heights in search of a favorable steady air current and had finally settled to an easterly course. Eight of the balloons were reported while crossing Indiana and Ohio as sailing in an easterly direction. Late Oct. 22 Maj. Henry B. Hersey, of the United States Weather Bureau, in the balloon "United States," descended on the shores of Lake Ontario, some 650 miles, in a direct line, from St. Louis. This was the shortest course with the exception of the English balloon, which descended half way across Ohio on account of the sickness of the pilot. It should be noted that Maj. Hersey was the one competitor who has made a close study of air currents in this country and was the only one who was able to maintain the northeasterly course which the pilots hoped to follow. However, he was handicapped by a leaking balloon, and, with his ballast almost exhausted, he was obliged to descend on seeing Lake Ontario. Without these handicaps he should have been able to hold the current which he had found and to have crossed Lake Ontario, when he would have had a clear field of hundreds of miles further before reaching the Atlantic Ocean. This is indicated in Fig. 1, which shows the general course of the nine balloons competing.

Fig. 2 indicates the method used by Maj. Hersey. It is seen that by remaining at the lower altitudes at first Maj. Hersey followed the tactics by which Lieut. Lahm won the first race.

Early Oct. 23 the remaining balloons began to descend along the Atlantic coast. First the German "Pommern," bearing Messrs. Oscar Erbsloch and H. H. Clayton was reported at Asbury Park, N. J. Shortly after the French

*Reproduced with diagrams from "Engineering News," Nov. 14, 1907.

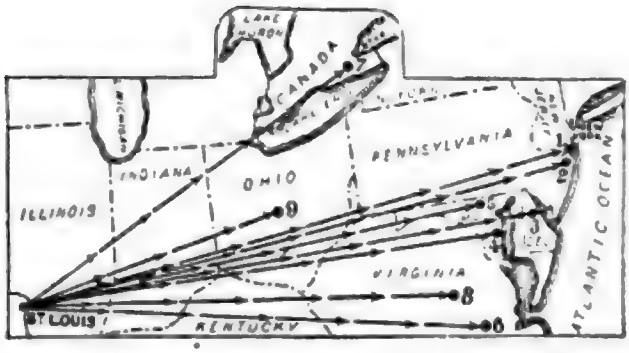


FIG. 1. GENERAL COURSES OF THE BALLOONS IN THE ST. LOUIS INTERNATIONAL RACE.

(1) The Pommern, (2) L'Isle de France, (3) Düsseldorf, (4) The St. Louis, (5) The America, (6) The Abercron, (7) The United States, (8) The Aujan, (9) The Lotus II.

(Reproduced from "The Scientific American," Nov. 2, 1907.)

"L'Isle de France," with Messrs. Alfred Le Blanc and M. E. Mix descended not far from the "Pommern," and further to the south the German "Düsseldorf" was reported on the edge of Delaware Bay. Four other contestants stopped still farther south without crossing Chesapeake Bay.

The distances traversed were estimated from data furnished by the United States Geological Survey to the Aero Club of America and the awards have been made only tentatively and subject to the final decision. However, it is not probable that there will be enough change in the records to change the awards already announced. The "Pommern" has been thus tentatively adjudged the winner with a record of 876 mi. "L'Isle de France" traveled 870¾ mi., which is slightly under the record of the "Pommern." However, this French balloon established a record of duration of time aloft of 44 hrs. and 2 min., which is 8 hrs. and 22 min. longer than the record of Count de la Vaulx in his long trip from France to Russia, when he established the distance record of 1,193 mi.

The recording barometers carried on each balloon were of the Jules Richard type of modified aneroid constructed so as to register up to 5,000 meters, or about 16,000 ft. altitude. In Fig. 2 is reproduced the record of the "United States" as shown by the original "barograms," but without barometric and other corrections, so that it shows only approximately the altitude of the balloon during its flight.

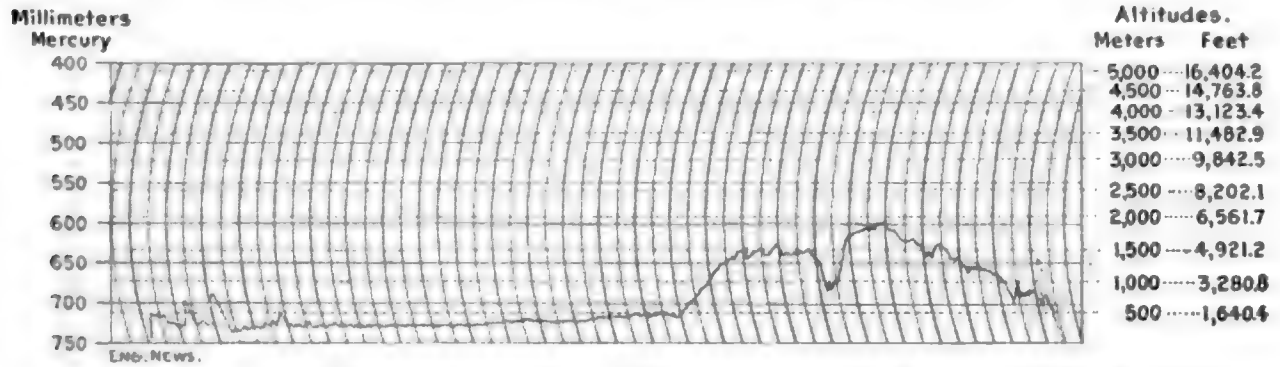


FIG. 2. RECORDING BAROMETER RECORD SHOWING THE TRIP OF THE "UNITED STATES."

PROGRESS WITH BALL AND ROLLER BEARINGS

By S. S. EVELAND

CONDENSED FROM "AMERICAN MACHINIST"

Great progress has been made in ball making, in many ways, during the past five years, during which time the accuracy of size and sphericity has improved from a possible limit of 0.002 inch plus or minus to a difference now in the best of balls of 0.0001 inch, plus or minus. An equal improvement has been secured in the strength and durability of balls, due to the use of special alloys of crucible, high-carbon steels. By the use of these special standard alloy steels, the crushing strength of balls of the highest grades has been raised over 100%; a ball of a given size that would formerly have crushed at 25,000 lbs. now requires 50,000 to

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55,000 lbs. to crush it. In consequence of this improvement in the strength of balls, they may now be applied and used where formerly it was not possible, owing to lack of sufficient space for the use of the proper size, but it is now practical to use a smaller size than formerly, to accomplish the result desired. Some evidence of the importance and size of the ball business is shown in the quantity of balls made in this country, which exceeds 600,000,000 per annum.

In ball bearings of a special type, the greatest development is in the form known as the annular ball bearing, which consists of two concentric rings having grooves in the inner and outer face, in which the balls revolve and have a bearing surface of a considerable part of their radius. There is no adjustment, which was formerly a feature of all types of ordinary cup and cone form of bearing, but which is not necessary or desirable, in the improved type of annular ball bearing. This bearing is made of special alloy steel, and has been used successfully for many purposes where the old cup and cone, made of case-hardened machinery steel, failed in operation. Bearings of this character have been used successfully on motors and generators and have added 10 to 15% to the efficiency of the electrical apparatus on which they were used.

In roller bearings, even a more rapid development has taken place than in ball bearings. Among the uses to which they have been applied during the past five years with exceptional success is on trolley-car journals.

The saving in current consumption is very great, as is indicated in a test run of two cars, practically alike and run under the same conditions, one having the ordinary plain bearing, and the other fitted with roller bearings. The test was on three-mile run, which is nearly straight except for one short 90° curve. One car was equipped with roller bearings, while the other had ordinary plain bronze bearings and the tests were as nearly identical as possible. The time of runs was nearly the same, but the consumption of energy was only 3.1 kilowatt-hours for the roller bearing as against 6.45 for the other.

The saving secured may seem large, but is confirmed by further tests made in which it was demonstrated that the net cash saving in coal consumption or its equivalent is $260 per car, per annum, in addition to which there is a very considerable saving in wear and tear which occurs on the ordinary brasses.

One test made by the Federal Government some time ago, of an army wagon fitted with and without roller bearing axles, demonstrated a saving ranging from about 52% up hill to as high as 75% on an asphalt drive.

An electric cab will run from 25 to 35% farther on one charge with roller or ball bearings than when using plain bronze bearings. In using shafting hanger bearings a recent test showed that 18 heavy grinding machines, using 49 HP. with the plain babbitted bearings, used only 27 HP. when roller bearing shafting hangers were used.

CHLORIDE OF CALCIUM IN REFRIGERATION

Chloride of calcium is being used more and more instead of salt in refrigeration, and those who substitute it for common salt will never go back to the other. Salt always contains a large amount of impurities, and its iron-destroying effect makes it rather costly in the end. It should be borne in mind that when a pipe is attacked from both sides its life will be rather short. This is also the case with the tanks containing the salt brine, and with pumps for handling it. This, as well as the great majority of other troubles that are experienced in using salt brine, is avoided when using chloride of calcium. It seems to pass through the pipes with less friction, and parts which were in use for a long time, showed upon removal that no corrosive action had taken place inside. Chloride of calcium also has a much lower freezing point than common salt brine, and is therefore better suited for places where a low temperature is required—"The American Brewers' Review."

JOHN KEATS

JOHN KEATS was born in London on October 31, 1795. His father died when he was eight years old, and his mother when he was fourteen. He was apprenticed to a surgeon, but soon abandoned medicine for poetry. His first volume appeared in 1817, and was followed by *Endymion* (1818), *Lamia, Isabella, The Eve of St. Agnes, and Other Poems* (1820). He died in Rome on February 23, 1821, and was buried in the Protestant Cemetery there.

NOTES ON ENGINEERING AND APPLIED SCIENCE FROM ALL SOURCES

Fireproofing Woods and Fabrics.—A French formula for this purpose consists of, according to "The Mechanical Engineer": sulphate of ammonia, 135 grams; borate of soda, 15 grams; boric acid, 5 grams; water, 1,000 grms.

Friction Losses in Countershafting.—According to Mr. L. P. Alvord, in a recent issue of "American Machinist," the average percentage of friction load to total load in a number of machine shops is 44.6. Five-sixths of this loss occurs in the distributing shafts and the countershafts of the various machine tools.

Tinol is a new soldering flux recently brought out in Germany. It is composed of tin and lead, reduced to an impalpable powder and then mixed with chloride of zinc. This compound is then made into a paste by the addition of vaseline or glycerine. It is stated that no oxidation takes place when it is used, and that the joints soldered with it are unusually clean.

A New Electromagnetic Track Brake.—Tests were made about a month ago in Leeds, Eng., of a new electromagnetic brake for trolley cars, the invention of A. W. Maley, one of the assistant engineers of the tramway department of the Leeds Corporation. The brake is operated in the first place as an ordinary slipper brake, or it can be used from the controller as an emergency brake energized from the motors. Thus the brake is first of all put upon the track as an ordinary slipper brake for coasting or service stoppages, and in case of emergency is used as a rheostat brake. The brake showed that it was entirely capable to do the work for which it was designed. Two of the most satisfactory tests gave the following results: speed of car on application of the brake, 19.7 miles; amperes per motor, 80; volts per motor, 446; distance required to stop car, 60 ft. Test No. 2: speed on application of the brake, 24 miles; amperes per motor, 80; volts per motor, 765; distance required to stop car, 132 ft. As a result of these favorable trials, three cars fitted with the magnetic brakes have been put into service in Leeds.—From "The Electrical Engineer" (Lond.).

Color Values of Artificial Lights was the subject of a paper recently read before the Electrical Section of the Western Society of Engineers, by H. V. Allen. The writer gave the predominating colors of different illuminants as follows:

Enclosed arc lamp (about 110 volts), clear globes, bluish white; with opal globe and diffuser, white.

Enclosed arc lamp (3¼-ampere, 140-volt, direct-current), violet (beyond color correction).

Nernst lamp (new glower), pale lemon-yellow; with seasoned glower, deep lemon-yellow.

Incandescent lamp, new, yellow; seasoned, pale orange-yellow.

Welsbach and vapor hydrocarbon lamps, new, greenish white; seasoned, greenish yellow.

Ordinary gas flame, reddish yellow.

Mercury-arc lamp, blue-green.

The preponderance of bluish rays of the arc lamp can be corrected by using opalescent globes and proper reflectors. The enclosed arc lamp can be corrected by using opalescent diffusers was advocated as producing the whitest light and therefore the closest approach to daylight. For this reason, it was stated, it was best suited for the illumination of dry goods stores where color values are of great importance. Even distribution of light and absence of direct rays were other advantages of these arc lamps.

Monox.—When silica, ordinarily in the form of glass-maker's sand, is heated in contact with coke, graphite or silicon carbide, silicon monoxide or "monox" is produced. Monox is a brown powder which is so extremely voluminous as to weigh only about 2½ lbs. per cu. ft., though its true density is about 2.24. One of the most interesting

properties of monox is that it is negatively electrostatically charged very powerfully on the slightest provocation, such as drawing it suspended in dry air through a short rubber pipe. When so charged it flies and adheres to all non-conducting surfaces, such as a cotton or other fabric, without caking together or materially hindering the passage of a gas. A screen of this character, coated with adhering monox, is impervious to fine solid particles, such as those constituting cigar smoke, or the fine particles formed when gaseous ammonia reacts with gaseous hydrochloric acid. Germs and all such organisms are stopped, so that air drawn through such a screen is absolutely sterile. This makes it probable that monox will find extended application in institutions like hospitals, but this must be investigated before any authoritative statement regarding its value in this field is made. Monox is also used as a pigment in certain paints, and in competition with other pigments has shown very gratifying durability.—H. N. Potter, in "The Electrochemical and Metallurgical Industry."

Cadmium and Its Uses.—During the last few years cadmium has met with increased interest. A new plant for producing it has been erected at Joplin, Mo., and several new uses for the metal have been discovered. Cadmium is usually obtained from its ores by the dry processes—i. e., by distillation. It usually occurs as the carbonate in all zinc ores, but in a smaller percentage than the zinc. The principle on which the distillation process of obtaining cadmium is based is that metallic cadmium evaporates at a far lower temperature than metallic zinc. The property of cadmium which gives it value in the arts is its ability to enter into combinations with other metals, thereby lowering the melting point. Various alloys of this kind are used as solder; Lipowitz's metal, for example, melts at 158° F. and tin, lead and Britannia metal can be soldered with it in water. In soldering German silver, brass or zinc with this metal, muriatic acid must be used to roughen the surface. This alloy consists of 4 parts of tin, 3 of cadmium, 15 of bismuth and 8 of lead. It has a luster exactly similar to that of polished silver, is tough, and can be bent, hammered and turned. Another alloy of cadmium which is being used considerably is one composed of platinum, copper, nickel and cadmium. It is used in watches and clocks where a tough, elastic and ductile metal is required, and one which at the same time must be non-magnetic. Cadmium also finds an extensive use as a pigment in the form of cadmium sulphide. Other of its compounds are used in photography, dyeing, and in medicine. The price of cadmium fluctuates widely, varying from $95 to $105 per 100 lbs.—Paul Speier in "The Mining Journal" (Lond.).

Oxygen in the Arts.—Various factors have hitherto militated against the general application of oxygen in the arts and industries, the principal being the impossibility of obtaining it in large quantities at a low cost. The rapid development which is taking place in the application of Dr. Carl von Linde's method of producing oxygen from the atmosphere by fractionation, offers reason for the belief that a more general use will be made of oxygen, particularly in metallurgical operations in the future. It is probable that in most cases oxygen will not be employed in a state of purity, but will be used for the purpose of adding from 5 to 10% to the quantity present in the normal air supply. In the case of a blast furnace the enrichment of the blast by the addition of 5% of oxygen would have marked effects, which should be distinctly beneficial. One result would be to reduce the capacity of the blowing engines by 20%. A plant to produce oxygen may soon become a necessary adjunct to the blast furnace. On such a scale the cost of the oxygen would be reduced to a very small amount. It is probable that considerable economy would be introduced into other smelting operations by the use of oxygen, as in the reduction of copper, and in the production of zinc, nickel and other metals. For the production of Bessemer steel the addition of a small quantity of oxygen during the first part of the blow would provide a means for reducing the time necessary for the operation. It would seem that the process lends itself particularly to this application in view of the small amount of silicon in much of the ore in this country.—Cecil Lightfoot, in "The Electrochemical and Metallurgical Industry."

Manufactured Graphite.—One of the most important electrical industries at Niagara Falls manufactures graphite from anthracite coal and petroleum coke and converts into graphite the forms of raw carbon used in electric furnace work, where high temperature is required, and for electrolytic work, such as the manufacture of caustic sodas, bleaching pow-

ders, etc.—in fact, practically all methods of electrolysis. The raw materials used consist of anthracite coal, glass sand, foundry coke, and sawdust, all of which are imported from the United States, except the sawdust. The furnaces used for the conversion of the anthracite coal or petroleum coke into graphite are in the form of long narrow troughs, built of firebrick and lined with some suitable refractory or insulating material. In this case the sand, coke, and sawdust are used for insulating, by mixing them together in the proper proportions. At the end of each trough is a terminal built of carbon rods, to which is connected the cables conveying the current. The trough is filled with anthracite coal, in which is embedded a carbon rod to make electrical connection between the terminals, as the coal is a very poor conductor of electricity. The temperature to which the coal is raised before conversion into graphite is very high, and is said to approximate 7,500° F., a temperature at which all bodies except carbon are vaporized and driven off. It is possible to make the graphite practically chemically pure, but for ordinary commercial purposes such a high degree of purity is unnecessary, but it is possible to so regulate the operation that a degree of uniformity of purity is attained which is not possible to secure in the production of natural graphites. When the furnace has cooled sufficiently the graphite is removed, but it is not yet in commercial form and has to be ground to powder and finally separated into the sizes necessary for the various uses to which graphite is put, one of the most important of which is its application as a protective coating for iron and other metal structures. During 1906, 454,311 lbs. of graphite were manufactured here, the greater part of which was exported to the United States.—"Mining and Scientific Press."

An Instrument for Testing Hardness.—The scleroscope, devised by Mr. Albert F. Shore, and described in detail in a recent issue of the "American Machinist," consists of a vertical glass tube about 10 ins. high,and a small pointed hammer weighing about 40 grains. This hammer is made of steel, treated so that it possesses jewel hardness and has a very small convex tip. When allowed to drop from the top of the tube this hammer makes a slight indentation in the material to be tested and then rebounds. The height of the rebound is used in preparing a comparative scale of hardness of various materials. Taking hardened carbon steel as 100 and soft brass as 10, the following comparative values have been determined:

Lead, cast	2
Babbitt metal, cast	4 to 9
Brass, soft, cast	7 to 10
Brass, hard, cast	20 to 25
Brass, rolled	26
Gold coin	14
Copper, rolled	14 to 20
Zinc, rolled	20
Zinc, cast	8
Nickel, cast	27
Silver coin	34
Iron, hot rolled	18
Iron, cold rolled	35
Iron, gray, cast	39
Iron, gray, cast, chilled	50 to 90
Steel railroad rails, 0.45 to 0.50 carbon, annealed	26 to 30
Steel, tool, 1 and over, carbon annealed	31
Steel, tool, 1 and over, carbon unannealed	40 to 50
Steel, tool, 1 and over, carbon cold-rolled drill rod	35 to 40
Steel, tool, manganese self-hardening	60 to 85
Steel, high-speed	100 to 105
Steel, tool, carbon	90 to 110
Porcelain	120
Glass	130

(These figures are subject to slight variations owing to the nature of the composition or compression of metals.)

POPULAR TECHNICAL MISCELLANY

THE NEWER CHEMISTRY

Dalton's theory was that all matter is composed of small particles to which he gave the name atoms. As the name implies, these particles were considered indivisible. Each atom had a certain weight. The atom of oxygen, in his view, weighed eight times as much as the atom of hydrogen, the atom of carbon six times as much, and the atom of chlorin thirty-five times as much. Compounds consisted of combinations of different kinds of atoms; in elements the atoms were all alike. The smallest quantity of a compound must contain at least two atoms, and larger quantities were made up of a number of these smallest quantities.

Later the groups of atoms came to be called molecules, and it was sometimes a question how many atoms of each kind there were in the molecule. Upon the answer given to this would depend the relative weight assigned to the atoms. It is calculated that in a gas more than 150 million million million molecules are contained in a cubic inch, and the molecules of many gases are composed of a considerable number of atoms. Moreover, the molecules are comparatively very far apart in a gas.

Another method of showing the probable size of molecules is the following: Suppose a drop of water were magnified to the size of the earth, the molecules would be between the size of a cherry and that of a cricket ball.

And now we are brought to the newer chemistry. Dalton's new chemistry taught that the atom is the smallest particle of matter existent; that the atom is indivisible. The newer chemistry admits that the atom is indivisible in the sense that we cannot divide it. The chemist may separate one atom from another atom, but he cannot divide the atom itself. But according to the newer chemistry, though we cannot divide an atom, the atoms of some substances and possibly of all substances decompose of their own accord.

Some forty years ago Crookes made a very interesting investigation into the passage of electricity through rarified air and other gases inclosed in glass tubes or bulbs. Platinum wires fused through the glass terminated inside and constituted electrodes—that is, the means by which the electricity was communicated to the gas. The wires outside the tube were connected with the positive and negative poles of an electric machine. The electrode connected with the positive pole is called the anode; the one connected with the negative pole is called the cathode. The passage of electricity through these tubes produces wonderful effects.

If the gas is not too much rarified a brilliant glow appears in the tube, not continuous, but like luminous disks at right angles to the path of the electric current. If the gas is sufficiently exhausted a dark space shows around the cathode, and if the gas is still further rarified, the dark space grows and may fill the whole bulb, if the exhaustion is carried very far. But in this case the walls of the bulb shine with a brilliant glow called fluorescence. Crookes maintained that the phenomena were not to be explained, except on the assumption of particles much smaller than atoms shot out from the cathode.

The attention of the world at large was drawn to the matter by Roentgen's startling discovery of the photographic effect of electric discharge in exhausted bulbs. It can be proved that small particles are shot from the cathode in straight lines. If the cathode consists of a flat disk the particles are sent out in parallel rays; if the cathode is a portion of a sphere the rays converge to the center of the sphere. The particles are very small, only about one-thousandth the weight of the hydrogen atom, and each has a charge of negative electricity as is proved by the fact that they are attracted toward a positively electrified body and are repelled by a negatively electrified body. Their velocity is between 20,000 and 60,000 miles a second. It is not possible in this short article to show how these conclusions are arrived at, but they are generally admitted by investigators of the subject. These

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very small particles are sometimes called corpuscles and sometimes electrons.

A little more than ten years ago Becquerel discovered that uranium compounds produce some of the effects hitherto obtained only by electric discharge through exhausted gases, and shortly afterward Mme. Curie separated radium from pitchblende, the most important ore of uranium. Radium was found only in very small quantity, but its effect proved to be very powerful. Further investigation by Rutherford and others shows that from radium compounds two kinds of particles are sent out. One kind is about twice the weight of the hydrogen atom, and has a charge of positive electricity. The other kind is similar to the corpuscles which constitute the cathode rays. The first form what are called the alpha rays; the second, beta rays. The electric charge upon the particles is determined as in the case of the cathode rays. It is found that the alpha rays are attracted by a negatively electrified body, while the beta rays are attracted by a positively electrified body. The beta rays are those that most concern us at this time, since they consist of electrons which, as stated, are smaller than the lightest atom known.

Since radium sends out particles as stated, it seems evident that it is decomposing. The beta particles are emitted in inconceivable numbers. It is calculated that each grain of radium shoots out 200,000,000 corpuscles each second with a velocity nearly equal to that of light. So small are these electrons, however, that if these were the only particles emitted it would take millions of years for the radium to be dissipated. The particles of the alpha rays are much larger, and are given off more numerously, and on that account a few thousand years only are needed for the almost total dissipation of radium.

The present theory regarding the composition of matter is that all atoms are made up of electrons; in the hydrogen atom there are approximately 1,000, in the atom of radium there are 225 times as many. Each of the electrons is charged with a definite quantity of negative electricity, but the atom is not charged because the negative electricity is counterbalanced by an equivalent positive. How the positive electricity exists is not definitely settled.

One atom differs from another of a different element in the number of electrons, and possibly also in their arrangement one atom may change to another by losing a certain number of electrons. So it is conceivable that the lead atom might change to a gold atom, and we should have the problem solved for which the old alchemists desired the philosopher's stone.

The dream of the old alchemists is still unfulfilled. If it should in the future attain fulfillment the era of the newest chemistry would be inaugurated.—Prof. John Waddell, in the "New York Times."

THE LUMIERE AUTOCHROME PLATE*

The latest advance in the science of color photography is the Lumiere autochrome plate. Briefly stated, the general procedure is as follows: A glass plate receives a coating of potato-starch grains—about 5,000,000 per sq. in.

These grains are impregnated with a dye. In a certain sense the method is a variation of the three-color process; only the colors used are not those which are ordinarily considered primaries—red, yellow and blue—but light green, red-orange and blue-violet, which are distributed throughout the particles in equal proportions.

After isolation with waterproof varnish, the granulated surface is coated with a panchromatic collodion emulsion. The exposure may roughly be said to be twenty times as long as one on a fast plate, and is made in an ordinary camera without any extra apparatus, the plate having its glass side turned toward the lens. The light passes through the colored grains and then strikes the light-sensitive film. A special yellow screen is placed before or behind the lens to retard the action of blue rays.

After developing, the plate, without fixing, is treated with acidified permanganate of potash, which acts as a reducer. This and the further process is undertaken in broad daylight. After reduction the plate is rinsed and redeveloped, the result being a positive transparency in natural colors, which, to be seen, must be held up to white light. At present no duplicates are possible, nor is it possible to remedy any faults by means of retouching.

*From "The New Color Photography" by J. Nilsen Laurvik in the Century for January.

BOOK DEPARTMENT

ALTERNATING CURRENT MOTORS.—By A. S. McAllister, Ph. D. Second Edition, revised and enlarged. New York: McGraw Publishing Co. Cloth; 6 × 9 ins.; pp. xi + 303; 131 illustrations in the text and many tables. $3, net.

That a second edition of this work has been called for within a year, speaks well for the treatment accorded by the author to his none too simple subject. In preparing the text the author assumed on the part of the reader a general knowledge of the fundamental principles of electricity and magnetism, together with a working acquaintance with the lower branches of mathematics. Both graphical and algebraical methods are employed, and the endeavor of the author has been to present his subject in the simplest manner consistent with the demands of accuracy. Some of the more important additions and changes noticed in the present volume are as follows: An extended discussion of the motor converter; a chapter on the leakage reactance of induction motors; an analysis of the magnetic field in induction motors; diagrams and explanations of circular current loci and V-curves of synchronous motors; an appendix treating of the leakage reactance of induction motors. In preparing this edition the author has availed himself of valuable suggestions solicited and received from many competent critics, including a number of instructors who have adopted the work as a text for their classes. Minor changes have been made in a number of places in order to more thoroughly clarify the presentation. Chapter titles are: Single-Phase and Polyphase Circuits; Outline of Induction Motor Phenomena; Observed Performance of Induction Motor; Induction Motors as Frequency Converters; The Single-Phase Induction Motor; Graphical Treatment of Induction Motor Phenomena; Induction Motors as Asynchronous Generators; Transformer Features of the Induction Motor; Magnetic Field in Induction Motors; Synchronous Motors and Converters; Electromagnetic Torque; Simplified Treatment of Single-Phase Commutator Motors; Motors of the Repulsion Type Treated Both Graphically and Algebraically; Motors of the Series Type Treated Both Graphically and Algebraically; Prevention of Sparking in Single-Phase Commutators; The Leakage Reactance of Induction Motors.

SANITATION OF PUBLIC BUILDINGS.—By William Paul Gerhard, M. Am. Soc. M. E., Consulting Engineer for Hydraulic and Sanitary Works. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4¾ × 7½ ins.; pp. 262. $1.50; English price, 6s. 6d., net.

The author of this work divides public buildings into three classes, distinguishing those having a permanent population at all times of the day or night, such as prisons, hospitals, asylums and homes for aged people; those having a large gathering of persons only during the day, such as schools, courthouses and markets; and finally those in which people congregate for a few hours only, either in the day or at night, as, for example, churches and theaters. As a result of this classification the book is naturally divided into five chapters. Chapter I deals with Hospital Sanitation. Drainage and sewerage are thoroughly discussed and all features of the care and maintenance of the building are adequately dealt with. In Chapter II the author treats of Theater Sanitation. Prevailing unsanitary conditions in our playhouses are spoken of and methods of improving them given. The ventilation and lighting problems are covered in a way that shows the author's thorough familiarity with his subject. Church Sanitation is the subject of the third chapter and the same kind of problems, to a large extent, as arise in the discussion of theater sanitation, are here dealt with. In Chapter IV all the sanitary conditions which should prevail in schools are fully considered. The fifth chapter is devoted to the discussion of the Sanitary Features of Markets and Abattoirs. This work should prove of great value as a guide to all architects and builders. Many features, important from a sanitary standpoint, in which the architect who designs public buildings is almost habitually remiss, are duly emphasized and brought to the attention of the reader. The book should also prove of

great value to mayors and aldermen in small towns where the board of health is, as is frequently the case, either too inefficient or too poorly paid to give the proper attention to the sanitary features of the schools or other public buildings. The book is well written, and the layman who is interested in civic affairs will find it easy reading and not so technical in its terminology as to be tedious—a frequent fault in books of this kind. Both the binding and the typography of the book are good.

SPECIFICATIONS AND CONTRACTS.—A Series of Lectures Delivered by J. A. L. Waddell, C. E., D. Sc., LL.D., Author of "De Pontibus," etc., including Examples for Practice in Specification and Contract Writing; together with "Notes on the Law of Contracts," by John C. Wait, M. C. E., LL.B., Author of "Engineering and Architectural Jurisprudence," etc. New York: Engineering News Book Department. Cloth; 6 × 9 ins.; pp. vi. + 174. $1, net.

This book consists of a series of lectures on specifications and contracts delivered by Dr. Waddell before the student-bodies of two engineering schools, together with an appended section of notes on contract law prepared by Mr. Wait. These lectures attracted wide attention at the time of their delivery, as condensing into small space the essentials of the subjects treated, and in a form particularly adapted to the instruction of students. The first lecture takes up the subject of specifications, the various features of which are discussed with illustrations drawn from the lecturer's experience. The student is shown what should enter into the specifications, the effects of changes, careless phraseology, the interrelation of the various parts, the duties of the various parties, etc. Nearly every statement is augmented with an apt extract from a specification employed at some time or other by Dr. Waddell. This lecture is supplemented by a section containing forty set exercises of diverse character, giving data upon which it is intended that the student should base sets of specifications which he is enjoined to prepare for practice in writing such instruments. Before attempting this, however, he is advised to obtain and study one or more actual specifications for similar work as a guide to the proper preparation of his own. In the lecture on engineering contracts the features of contracts are considered in detail, and a number of examples of contracts are given, including the standard form in use by the lecturer in his engineering work. The conditions precedent for fourteen contracts to be drafted by students are then given, covering a wide variety of subjects. In the appendix Mr. Wait has dwelt not only upon the legal features of the various points brought up by Dr. Waddell in his lectures, but upon many others as well. The element of illustration and example embodied in this book will recommend it to professors in technical schools, giving as it does the results of the extended experience of two writers eminent respectively in the engineering and legal professions. Practicing engineers will also derive valuable suggestions and much profitable information from its perusal. The publishers announce that, in accordance with the request of Dr. Waddell, the price of the work has been made as low as possible in order that it may be within the reach of every engineering student.

INDUSTRIAL ALCOHOL.—The Production and Use of Alcohol for Industrial Purposes and for Use as an Illuminant and as a Source of Motive Power. By John Geddes M'Intosh, author of "The Technology of Sugar," etc., Lecturer on Manufacture and Applications of Industrial Alcohol, etc. London: Scott, Greenwood & Son. New York: D. Van Nostrand Co. 1907. Cloth; 5⅛ × 8½ ins.; pp. viii. + 252; with 75 illustrations and 25 tables. $3.00, net.

For many years manufacturers and others desiring to use ethyl alcohol industrially have, in certain European countries, been able to obtain it in an undrinkable form free from tax. After many years of agitation we have at last obtained in this country also a law giving us the use of alcohol, properly denatured, tax free for industrial purposes. In consequence, there has sprung up a demand for books relating to the manufacture and uses of such alcohol. Among these books is the one here reviewed. It deals chiefly with the methods of manufacturing that article employed in France and Germany, the two countries most prominent in its production.

The first chapter deals with some general questions relating to alcohol and its properties, and contains, among other things, the usual specific gravity, boiling-point and contraction tables for mixtures of alcohol and water.

The second chapter takes up the matter of fermentation of the raw materials in a general way, and explains the production of pure yeast cultures, the sterilization of air and of liquids, and continuous fermentation.

Chapter III. is devoted to the manufacture of industrial alcohol from beets. Details of the various methods of conducting operations most successfully are presented, with some illustrations, including valuation of beets for distillery purposes, washing, slicing, extraction, both by maceration and by diffusion, fermentation, aseptic and otherwise, and distillation apparatus. A large French plant is described and illustrated.

The fourth chapter deals with the manufacture of industrial alcohol from grain. The various operations and methods of storing grain, of malting, saccharifying and mashing are described and illustrated.

The manufacture of industrial alcohol from potatoes is rather briefly considered in Chapter V. Here the German excise regulations and methods are described.

In Chapter VI. the manufacture of industrial alcohol from waste fruit, spoilt wine and wine marc is discussed. This chapter is for American farmers a very important one, because eventually all sorts of waste and spoilt fruits, etc., will be utilized for making industrial alcohol. Some pits into which a novice may fall are pointed out and remedies suggested. Several plants, both large and small, for recovering alcohol from these wastes, are figured and described.

One of the raw materials from which a large quantity of cheap undrinkable alcohol is expected to be obtained is molasses, some varieties of which are now entirely useless. Chapter VII. deals with methods and apparatus suited to this source.

Chapter VIII.,which fills one-quarter of the book, treats in detail of the plant for distilling and rectifying industrial alcohol. Many types of stills and still-heads, and accessory apparatus, are thoroughly discussed, the good and bad points of each being pointed out.

Chapters IX. and X. deal with the manufacture of alcoholic derivatives and the manufacturing uses of alcohol.

Chapter XI. treats very briefly of the uses of alcohol for lighting, heating and motive power. Some lamps and heaters are figured. A good index closes the work.

This book will certainly be of great use in pointing out the successful processes in use abroad, and will, therefore, serve a highly important role in the development of American industrial alcohol.

The type and illustrations are clear, and the paper and binding are good.

HYDRAULICS.—By S. Dunkerley, D.Sc., M. Inst., C. E., Professor of Civil and Mechanical Engineering in the University of Manchester. New York: Longmans, Green & Co. Cloth; 8vo. Vol. I., Hydraulic Machinery; pp. viii + 343. Illustrated. $3. Vol. II., The Resistance and Propulsion of Ships (in press).

This work treats of the subjects of hydraulics and hydraulic machinery and was written for use in universities and the British Navy and for those engaged in the design of hydraulic apparatus. A second volume will consider the resistance and propulsion of ships. Chapter I. takes up the theory of flow of a perfect fluid under pressure or head; among the subjects discussed are Bernouilli's equation, the Venturi meter, coefficients of discharge for various openings and orifices, V-notches and other forms of issuing jets. Chapter II. discusses fluid friction, giving the quantitative expression for loss of head, Darcy's formula for the friction coefficient in cast-iron pipes, the line of virtual slope, transmission of power, horse-power, types of British and continental water meters, resistance of bends and elbows, and the effect of the angle of divergence on loss. Chapter III. is devoted to hydraulic pressure machines; the relative advantages of using steam and water are set forth and descriptions are given of accumulators, intensifying apparatus, differential accumulators, and methods of hydraulic riveting. Details are also given of the hydraulic gun brake as applied in the ships of the British Navy, and of the Eiffel Tower elevator, the operation of bulkhead doors, an 8,000-ton hydraulic press and hydraulic engines and cranes. Chapter IV. is given up to reciprocating pumps and treats of bucket pumps, single and double-acting plunger pumps, slip, the effect of air chambers, hydraulic governors, hydraulic rams, the Reidler pump, Worthington high-duty pumps and the Gutermuth valve. Chapter V. deals with water turbines, giving the theoretical considerations involved in their design and operation and supplementing this by descriptions of a number of European turbines, including Prof. Osborne's four-stage turbine. Chapter VI. treats of centrifugal pumps and Reynolds' hydraulic brake. The closing chapter is devoted to a description of the experimental investigations of Prof. Osborne for determining whether the motion of water should be direct or sinuous, and of the law of resistance in parallel channels, as well as his work in connection with the theory of lubrication. Sixty-six problems are given in an ap-

pendix. The details of Prof. Osborne's researches and the descriptions of certain apparatus before-mentioned make the work a desirable addition to recent hydraulic literature. Some mispellings of proper nouns will doubtless be corrected in future printings.

TABLES.—By Edward Godfrey, Structural Engineer for Robert W. Hunt & Co. Second Edition, revised and enlarged. Pittsburg, Pa.: The Author. Flexible morocco; 4 × 6½ ins.; pp. 218; with many illustrations. $2.50 (in clubs of 5, $2 each).

This is the second edition of a concise handbook, containing in convenient form those tables, formulas, and data of everyday use to designers, computers and draftsmen engaged in structural steel work. Tables giving the properties of the various Carnegie steel sections are reproduced with the consent of the company. Two pages are given up to tables for quickly calculating the weights and areas of angles. Eight pages are devoted to formulas for bending moments, and deflections of beams and girders, tables of working stresses, weights of substances, and miscellaneous formulas for corrugated sheets, cylinders and spheres, brake bands, springs, flat plates and rings. This matter is concisely stated and some of it is not otherwise readily accessible. A table is given for expediting calculations of the moment of inertia of built-up symmetrical sections. About a dozen pages are given up to diagrams and formulas for calculating stresses in roof trusses. These are almost entirely new, and their use avoids the confusion incident to calculations involving angles and their functions. Tables of loadings occupy ten pages and are intended to facilitate the computation of bending moments and weights of girders. Twenty-four pages are devoted to tables of angles, Z-bars and built sections, and are so arranged that values for intermediate sizes may be obtained by interpolation. Thirty-eight pages are filled with line drawings of typical details of steel, reinforced concrete and masonry constructions, which are for the purpose of placing before the user of the book examples of approved modern practice. The usual tables of squares, cubes, square roots, etc., are included, together with many others which it is not possible to enumerate in this notice. The author is an engineer with something like 16 years' experience in structural designing, and he has gathered into small compass and convenient form a large amount of necessary data that has hitherto been obtainable only by consulting a number of separate reference works. Many original tables are also included, which have been prepared for the purpose of facilitating various computations of frequent occurrence.

ENGINE-ROOM CHEMISTRY. — A Compend for the Engineer and Engineman. By Augustus H. Gill, S. B., Ph.D., Associate Professor of Technical Analysis at the Massachusetts Institute of Technology, Boston, Mass. Published serially in "Power." First Edition. New York: Hill Publishing Co. Cloth; 5 × 7 ins.; pp. 198; 12 tables and 47 figures in the text. $1.

The object of this little work is to give the engineman a sufficient knowledge of the principles and practice governing the analysis of fuels, gases and water to enable him to make such tests as are necessary to obtain the highest efficiency possible in the operation of his boiler.

The book is not intended to appeal to the chemist or technical man. It is too elementary to do this. On the other hand, it is hardly practical to give the uneducated man a volume which, in one hundred pages, tries to give him sufficient knowledge to enable him to undertake analyses which the student of chemistry never performs until he has studied the fundamental principles on which such analysis is based, for at least a year or a year and a half. It is not possible for the average man to do such work on a basis of such theoretical knowledge as may be gained from the book. If, however, it will stimulate the man behind the engine to study the principles involved in its operation a great deal will have been accomplished by the author.

The first two chapters are introductory and contain a discussion of some of the elementary chemical principles and a description of apparatus. The third chapter defines and describes various fuels and describes methods used in analysis. The regulation of combustion and analysis of gases are dealt with in the fourth chapter, and a description of various types of automatic apparatus is here given. The next three chapters are probably the most valuable in the book and contain considerable information which will be of value to the engineman. Water, boiler scale and its prevention, pitting and corrosion, and the various lubricants and the methods to be followed in their selection are discussed in a fairly full and decidedly helpful manner. An appendix contains various tables which give such facts as the melt-

ing points of salts and metals, the relation of the Fahrenheit and Centigrade scales, and the weights per gallon and specific gravity of certain oils.

THE MECHANICAL ENGINEER'S REFERENCE BOOK.—A Hand-Book of Tables, Formulas, and Methods for Engineers, Students, and Draftsmen. By Henry Harrison Suplee, B. Sc., M. E., M. Am. Soc. M. E. Third Edition, revised and enlarged. Philadelphia and London: J. B. Lippincott Company. Flexible morocco; 4 × 6¾ ins.; pp. xii + 922; with over 400 illustrations in the text. $5, net; with thumb index, $5.50.

This handbook of mechanical engineering information, compiled by the editor of "Cassier's Magazine," has passed through two editions, and now appears in its third, revised and enlarged by the addition of more than 100 pages of new matter. Over one-quarter of the book is devoted to mathematics and mathematical tables, the presentation being by far the most complete given in any similar hand-book printed in English. In the present edition these tables have been extended, and the added matter on other subjects includes data on ball bearings, machine elements, fuel tests, steam turbines and electrical installations. The book contains the A. S. M. E. codes for the testing of steam and gas engines, the uniform specifications adopted by the American Boiler Manufacturers' Association, and the National Electrical Code. Many tables for the conversion of English into metric weights and measures are given, and one feature of value is a table of the properties of steam in metric units. A very complete index of 44 pages is appended, comprising some 4,000 entries.

ELECTRO-ANALYSIS—By Edgar F. Smith, Professor of Chemistry, University of Pennsylvania. Fourth Edition, revised and enlarged. Philadelphia: P. Blakiston's Son & Co. Leather; 5½ × 7½ ins.; pp. viii + 336; illustrated with 42 text figures. $2.50, net.

In preparing the fourth edition of this excellent work for the press, the author found it advisable to omit considerable matter which was of purely historical value. The book loses nothing by this and the addition of new and excellent material serves to bring it parallel with the latest advances in electro-chemistry. The book is divided into two parts. The first contains considerable matter on the sources of the electric current, methods for reducing and measuring it. The history of electro-chemistry is briefly reviewed and new material on the rapid precipitation of metals and the use of the mercury cathode is here introduced. In this section the author also considers the theoretical side of the subject with which he is dealing. This chapter on "Theoretical Considerations" is probably the weakest feature of a strong book. Nine pages are hardly sufficient for the discussion of a most important and indispensable part of the subject. However, the author has condensed a great deal of value in these nine pages and the student who wishes to go more deeply into the matter is given many references on the subject. The second part of the book is devoted to the description of the methods used in electro-analytical work. The ground is well and thoroughly covered and the exact details of laboratory practice are given. They are given, furthermore, in just the way that the chemist likes. Clear, definite and brief, they go to make up the most valuable part of a book that is bound to win new friends among the profession in which it was already firmly established.

MATHEMATICAL HANDBOOK.—Containing the Chief Formulas of Algebra, Trigonometry, Circular and Hyperbolic Functions, Differential and Integral Calculus, and Analytical Geometry, together with Mathematical Tables. Selected and Arranged by Edwin P. Seaver, A. M., LL.B., formerly Assistant Professor of Mathematics in Harvard University. New York: McGraw Publishing Co. Cloth; 5 × 8½ ins.; pp. 279. $2.50.

This reference manual, aiming as it does to give the reader in concrete form, the results of mathematical work in the various fields of algebra, trigonometry, hyperbolic functions, differential and integral calculus, and analytic geometry, will find a wide use among engineers and mathematicians. Almost every variety of mathematical problem presenting itself to the man engaged in engineering practice can be solved by the use of this work. Besides this useful collection of mathematical formulas, the book contains an excellent collection of tables, which add greatly to its value. A list of these tables follows: Square, cubes, square and cube roots, cube roots of squares and reciprocals of numbers from 1 to 1,000; five-place logarithms of numbers from 1 to 10,000; binomial coefficients and factorial products, both up to 20; natural logarithms of numbers from 1 to 1,000; three-place trigonometric or circular functions by degrees; five-place tables of trigonometric functions by 10 minutes; five-

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place logarithms of trigonometric functions by 10 minutes; four-place values of circular and solid angles, circumferences and areas of circles and volumes of spheres for values from 1 to 200; dimensions of circular segments for central angles from 1° to 180°; natural values and common logarithms of hyperbolic sines, cosines and tangents; and tables of weights and measures, of the value of gravity in various places, and of the velocity, v, in the formula $v = \sqrt{2gh}$, for values of h of from 1 to 6,000.

FLYING MACHINES.—Past, Present and Future.—A Popular Account of Flying Machines, Dirigible Balloons and Aeroplanes. By Alfred W. Marshall, M. I. M. E., and Henry Greenly. New York: Spon & Chamberlain; London: E. & F. Spon, Ltd. Paper; 5 × 7½ ins.; pp. 128; illustrated. Price 50 cents.

This interesting little volume is intended as a popular exposition of the subject with which it deals. Any reader, however, who may have a serious intention of doing experimental work in the field of aeronautic navigation, will find in the pages of this book material which would be of undoubted assistance to him. A work of this character, which is largely a record of experimental achievement, cannot, of course, contain complete statements of the work of every investigator. Adequate summaries of the work of practically all the leading men who have accomplished anything worthy of note in this field, are given and frequent references to more detailed accounts are made for the benefit of those who wish to study the subject in greater detail. The book is divided into five chapters. Chapter I. contains a discussion of the principles upon which various experimenters have attacked the problem. Chapter II. treats of dirigible balloons and summarizes the work of those whose work has brought them to the fore in aeronautic navigation. Chief among these are, of course, the airships of Santos-Dumont and Henri Deutsch. The Walter Wellman dirigible balloon is also discussed. Chapter III. discusses true flying machines of the heavier than air type and the work of Archdeacon, Santos-Dumont, Langley, the Wright brothers and other experimenters is given in interesting form. Chapter IV. contains a short discussion on the art of flying, giving the advice of Lilienthal and Pilcher to experimenters. Chapter V. is devoted to the flying machines of the future and in it the authors touch briefly on what may be expected of future experiments of the field of aerial navigation.

THE MOTORMAN AND HIS DUTIES.—A Handbook of the Theory and Practice of Electric Railway Operation. By Ludwig Gutman, Consulting Electrical Engineer, Sixth Edition. Revised and enlarged by Lawrence E. Gould, Editor of the Electric Railway Review. Chicago, Ill.: The Wilson Company. Cloth; 5 × 7 ins.; pp. 198; illustrated with 138 text illustrations and 3 large inserts of car wiring diagrams. $1.50, net.

"The Motorman and His Duties" aims to outline in a simple way the fundamental principles underlying the operation of an electric railway car, and to explain to those who have not had the advantages of a technical education the relation between the power station distribution circuits and the car itself. It avoids mathematical discussions and technical language and is written for the employee of the electric railroad who does not thoroughly understand the principles connected with the operation of the machinery with which he has to do. In the first three chapters the roadbed and rolling stock of an electric railway are described, the essential principles of the electric motor discussed, and the generation and distribution of the electric current outlined. Chapter IV. treats of the conductor and the use of transmission lines. In Chapter V. the author deals with the constructional details of electric railway motors. Car wiring and parts, fuses, lightning arresters and wiring circuits are introduced in the following chapter. The next three chapters are devoted to a description and discussion of the various types of standard controllers. Chapter X. deals with brakes and their operation and the concluding chapter comprises methods of operation to be used to prevent and remedy troubles. That the aim of the volume has been accomplished may be fairly well judged by the fact that in nine years six editions of the work have appeared. This edition is considerably enlarged and has been thoroughly revised and brought up to date.

TABLES OF QUANTITIES FOR PRELIMINARY ESTIMATES.—By E. F. Hauch and P. D. Rice. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4 × 6¾ ins.; pp. 92; 5 figures in the text. $1.25; English price, 5s. 6d., net.

This little book contains very useful tables for calculating the volume of an embankment. The tables have been computed according to the prismoid formula, and give station yardages to the nearest cubic yard for roadway widths from 12 to 35 ft. with side slopes varying from ¼:1 to 1½:1, and center heights

varying by 1 ft. from 1 to 50 ft. Tables of toe slopes, cubic yards from the sum of end areas where the section length is 100 ft., chains reduced to feet, and fractions of an inch reduced to decimals of an inch, and acreage for right-of-way 100 ft. wide are also given. The railway surveyor will find the volume of use when making preliminary estimates according to the method employed by the authors.

TOOL MAKING.—A Manual of Practical Instruction in the Art of Making Tools, with Many Hints on the Solution of Problems Calling for Ingenuity and Mechanical Skill in the Devising of Special Means to Special Ends. By Edward R. Markham, M. A. S. M. E., Consulting Engineer; Author of "The American Steel Worker;" Instructor in Machine Shop Work, Harvard University. Chicago: The American School of Correspondence. Cloth, 6½ × 9½ ins.; pp. 206; 327 illustrations. $1.50.

This is another of the series of practical handbooks issued by The American School of Correspondence—referred to last month in this department. The first chapter discusses the general principles of toolmaking, including precise and approximate measurements, special tools and materials, tool steel, annealing, hardening, case-hardening, tempering, etc. The second chapter is devoted to the production of the various forms of drills, arbors, reamers and taps. In the third chapter threading dies, counterbores, hollow mills and the many forms of milling cutters are considered. The final section treats of jigs, bushings, punch and die work, gages and gagemaking, etc. The book is well illustrated, and should prove of value to young machinists who are desirous of advancing in their chosen work, and to draftsmen, who will find it extremely useful in giving them information on methods used in the production of machine parts in quantities, thus enabling them to conform their designs to the practice of the shop.

Messrs. Spon & Chamberlain, publishers, importers and booksellers, at 123-125 Liberty St., New York, have just issued, under date of Dec. 1, a new descriptive catalogue of books, including in addition to their own publications, those of Messrs. E. & F. N. Spon, Ltd., and Percival Marshall & Co., of London, for whom they are the American agents. This catalogue comprises 200 pages and lists about 500 works, distributed over some 350 subjects relating to the various branches of engineering, the industrial arts, trades and manufactures. A copy will be forwarded promptly to anyone upon receipt of a postal card request.

NEW BOOKS.

Chemistry.

SPECTRUM ANALYSIS.—By John Landauer, LL.D., Member of the Imperial German Academy of Naturalists. Authorized English Edition by J. Bishop Tingle, Ph.D., F. C. S., Professor of Chemistry in the McMaster University, Toronto. Second Edition, rewritten. Cloth; 6 × 9 ins.; pp. x + 236; 49 illustrations in the text. $3.

Civil Engineering.

HANDBUCH FUER EISENBETONBAU.—Edited by F. von Emperger. Vol. II.: The Material and Its Manipulation. Prepared by K. Memmler, H. Burchartz, H. Albrecht, R. Janesch, O. Rappold, A. Nowak. Berlin, Germany: Wilhelm Ernst & Sohn. Paper; 7¼ × 10½ ins.; pp. 243; 420 text illustrations and 1 folding plate. 12 marks; American price, $4.80.

HIGHWAY CONSTRUCTION.—A Practical Guide to Modern Methods of Roadbuilding and Development of Better Ways of Communication. By Austin T. Byrne, Author of "Highway Construction," "Materials and Workmanship," and Alfred E. Phillips, Ph. D., Professor of Civil Engineering, Armour Institute of Technology. Chicago, Ill.: American School of Correspondence. Cloth; 6½ × 9¾ ins.; pp. 136; 79 illustrations in the text and 2 plates. $1.

TESTS OF REINFORCED CONCRETE BEAMS.—Series of 1906. By Arthur N. Talbot, Professor Municipal and Sanitary Engineering and in Charge of Theoretical and Applied Mechanics. Urbana, Ill.: University of Illinois Bulletin No. 14; paper; 6 × 9 ins.; pp. 36; illustrated.

THE HARDENING PROCESS OF HYDRAULIC CEMENTS.—By Dr. W. Michaelis, Sr. A Paper Read at the Thirtieth Annual Meeting of the German Portland Cement Manufacturers' Association, at Berlin, Feb. 21, 1907. Translated by Dr. W. Michaelis, Jr. Chicago: Cement and Engineering News. Paper; 5¼ × 7¾ ins.; pp. 29. 50 cents.

THE PRACTICAL DESIGN OF IRRIGATION WORKS.—By W. G. Bligh, M. Inst. C. E., Executive Engineer Indian P. W. Department (Retired). New York: D. Van Nostrand Co. Cloth; 6¾ × 10¼ ins.; pp. 390; 249 illustrations, mostly in the text. $6, net.

Electrical Engineering.

A POCKET-BOOK OF ELECTRIC LIGHTING AND HEATING.—Comprising Useful Formulas, Tables, Data, and Particulars of Apparatus and Appliances, for the Use of

Central Station Engineers, Contractors, and Engineers-in-Charge. By Sydney F. Walker, R. N., M. Inst. E. E., M. Inst. M. E., Assoc. M. Inst. C. E., etc. New York: The Norman W. Henley Publishing Co. Leather; 4 × 6½ ins.; pp. xxviii. + 438; 272 illustrations in the text and 146 tables. $3.

A TEXT-BOOK OF ELECTRICAL ENGINEERING.—Translated from the German of Dr. Adolf Thomalen by George W. O. Howe, Assoc. M. Inst. E. E., Lecturer in Electrical Engineering at the Central Technical College, South Kensington. New York: Longmans, Green & Co. London, England: Edward Arnold. Cloth; 6 × 10 ins.; pp. 456; 454 illustrations in the text. $4.20, net.

ELECTRICAL TRACTION.—By Ernest Wilson, M. Inst. E. E., Professor of Electrical Engineering in the Siemens Laboratory, King's College, London, and Francis Lydall, Assoc. Inst. E. E. In two volumes. New York: Longmans, Green & Co. London, England: Edward Arnold. Cloth; 5½ × 8¾ ins. $4, net (each volume).
Vol. I.: Direct Current. Pp. 475; 271 illustrations, mostly in the text.
Vol. II.: Alternating Current. Pp. 328; 184 illustrations, mostly in the text.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS.—Written and compiled by a staff of Specialists. First edition, 1908. New York: McGraw Publishing Co. Flexible morocco; 4⅛ × 6¾ ins.; pp. xx + 1,283; 1,271 illustrations in the text, with innumerable tables. $4, net.

Gas Manufacture.

THE CHEMISTRY OF GAS MANUFACTURE.—A Practical Manual for the Use of Gas Engineers, Gas Managers and Students. By Harold M. Royle, F. C. S., Chief Chemical Assistant at the Beckton Gas Works. New York: The Norman W. Henley Publishing Co. London, England: Crosby Lockwood & Son. Cloth; 5½ × 8¾ ins.; pp. 328; 1 plate and 82 text illustrations. $4.50.

Mechanical Engineering.

CARBURETING AND COMBUSTION IN ALCOHOL ENGINES.—By Ernest Sorel. Translated from the French by Sherman M. Woodward, Formerly Professor of Steam Engineering, State University of Iowa, and John Preston. New York: John Wiley & Sons. London England: Chapman & Hall, Ltd. Cloth; 5 × 8¼ ins.; pp. 269; 26 illustrations in the text. $3; English price, 12s., 6d., net.

HOW TO USE WATER POWER.—By Herbert Chatley, B. Sc. (Engineering), Lecturer in Civil Engineering and Applied Mechanics, Portsmouth; Author of "How to Make a Survey," etc. London, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4¾ × 7¼ ins.; pp. 92; 23 illustrations, mostly in the text. $1, net.

MODERN STEAM TRAPS.—(English and American): Their Construction and Working. By Gordon Stewart. London, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4¾ × 7¼ ins.; pp. 104; 71 illustrations in the text. 3s., net; American price, $1.25, net.

NOTES ON THE CONSTRUCTION AND WORKING OF PUMPS.—By Edward C. R. Marks, M. Inst. M. E., Assoc. M. Inst. C. E., Author of "Notes on the Construction of Cranes and Lifting Machinery," etc. Second and enlarged edition. London, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4¾ × 7¼ ins.; pp. 259; 159 illustrations in the text. 4s. 6d., net; American price, $1.50, net.

A POCKET-BOOK OF MECHANICAL ENGINEERING.—Tables, Data, Formulas, Theory and Examples, for Engineers and Students. By Charles M. Sames, B. Sc., Mechanical Engineer. Third Edition, revised and enlarged. Jersey City, N. J.: The Author. Leather; 4 × 6½ ins.; pp. 195; 39 illustrations in the text. $2.

STEAM TURBINES.—By Carl C. Thomas, Professor of Marine Engineering, Sibley College, Cornell University. Third Edition, revised and enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xiii. + 334; with 145 figures and 20 plates. Price advanced from $3.50 to $4.

THERMODYNAMICS OF THE STEAM-ENGINE AND OTHER HEAT-ENGINES.—By Cecil H. Peabody, Professor of Naval Architecture and Marine Engineering, Massachusetts Institute of Technology. Fifth Edition, rewritten. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 533; 117 illustrations in the text. $5; English price, 21s., net.

Mining Engineering.

HYDRAULIC AND PLACER MINING.—By Eugene B. Wilson. Second Edition, rewritten. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 4¾ × 7½ ins.; pp. 355; plates, text illustrations and tables. $2.50.

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INDUSTRIAL ENGINEERING

esting. They are not riveted, but are retained by means of special edge links, called retaining links. These are thinner than the chain links and have one hole keyhole-shaped, which passes over the end of a pin and enters a circular groove in the pin. The retaining links are offset, and overlap and lock each other, as well as the pins, in place. By this construction the chain is securely held together and yet is easily detachable for general overhauling or changing its length without the use of tools. The pins require no annealing at their ends and are consequently free from soft spots and resist wear uniformly throughout their length.

The wheels on which these chains run have symmetrical cut teeth, the number being limited only by size of wheels the cutting machine will handle. Very large speed ratios are consequently possible, 20 to 1 being well within the limits. A drive can readily be reversed and the chains need not be placed on the wheels in any special manner.

The Schmidt chains also have the faculty of riding out on the wheel teeth as their pitch lengthens, automatically forming a larger pitch circle, and retaining their original efficiency, greatly increasing their life. The chains when engaging or leaving the wheels clear the teeth, eliminating all wear and friction from this cause.

These chains are the invention of Mr. Carl G. A. Schmidt, Jr., and are manufactured by the Schmidt Drive Chain Co., of 265 Broadway, New York City.

GOOD ILLUMINATION.

Good illumination involves three essential points: (1) The right quantity of light; (2) The right quality of light; (3) The right use of light.

For example: To read this page with the greatest ease, you would not hold it in direct sunlight, which would illuminate it too brightly; nor in the light of dusk, which would illuminate it too dimly; nor by a red light, which would be unpleasant to the eyes; nor would you let the light shine squarely onto the page and throw a direct reflection into the eyes; but you would choose a light of moderate intensity, such as that from a north window, or a good lamp covered with a globe to diffuse and soften the rays; and you would place the light at the side, and a little above the page, so that the paper would show no "shiny" spot, i. e., so that none of the light reflected directly would reach your eyes.

It may be put down as an established fact in artificial lighting that all modern light sources are too bright to be used uncovered, where the light is to be used for careful vision, such as reading or writing; they should either be enclosed in some sort of globe which will diffuse their light, or be placed so that the eye cannot see the source of light. If this rule is adhered to it will be found that none of the modern high-power lights are "too hard on the eyes."

Ground glass and so-called "porcelain" (opal glass) have long been used as a means of diffusing light. While they produce the desired softening, they accomplish the result at a very great waste of light, running all the way from twenty to seventy-five per cent. This so reduces the actual illumination as to practically offset the economy resulting from the higher efficiency of such lights as the mantle-gas burner and acetylene flame, and add materially to the cost of illumination of electric lamps, which are generally more expensive than the other light sources.

It was with a view of avoiding this serious waste of light that Holophane globes were invented. These globes are made of the purest crystal glass, having both inner and outer surfaces formed into a series of prismatic ribs and flutings, accurate to the thousandth part of an inch. These prisms are of such form as to diffuse and soften the light, and at the same time turn the rays which would otherwise go upward and be lost to practical use, into a downward and useful direction. This is accomplished by forming the prisms in accordance with the established laws of optics, just as a telescope or other optical instrument is designed for its especial purpose.—From a booklet issued by the Holophane Glass Co., Glackner Bldg., New York.

THE TREATMENT OF BELTS.

Two things are necessary for perfect belt service. First: pliable, healthy, vigorous belts, waterproof and clean, able and ready to work; Second: the prevention of slip.

There have been two ways of stopping slip. One by tension (tight belts) and the other by putting on some sticky material. The first way loads the belts, bearings, shafting and engine with a great dead drag of friction load. It is a wasteful way.

The second way hurts the belts, dries them out, uses up power to rip the belt off the pulley and often forms lumps, on top of which

conditions where steel formerly lost about 18% more than wrought iron. Numerous tests made in aerated brine in the National Tube Company's laboratory have given practically the same results. Two photographs of plates of wrought iron and steel, which have been tested side by side under these conditions for three months, are reproduced to show the comparative evenness and freedom from pitting of the steel surface. While the results figured in percentage lost per unit of surface exposed are in favor of steel made by this process, the fact that this material does not pit so readily as wrought iron is of far more importance to the user.

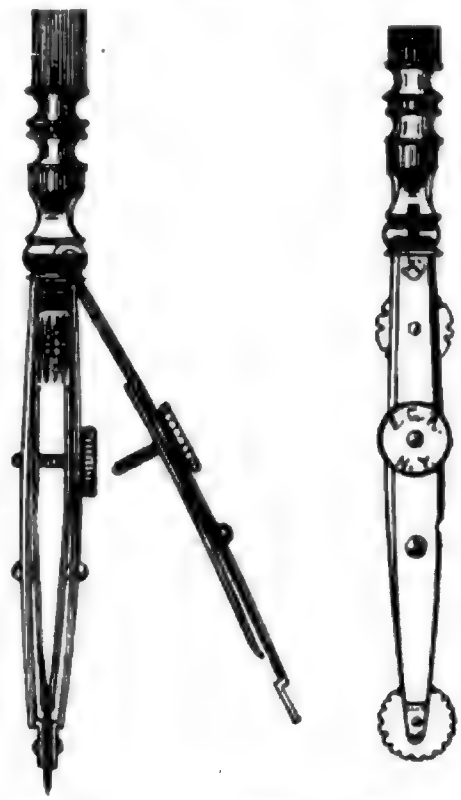
The new process by which this steel is treated is mechanical and does not in any way depend on skilled labor beyond keeping up the machinery involved, hence uniform treatment is assured.

Steel pipe has been shown to be superior to point of finish, strength of seam and uniformity of material, and it now appears that it can be made so as to have a decided advantage over wrought iron under corrosion.—From "The Manufacture of Welded Pipe," a pamphlet published by the National Tube Co., Pittsburg, Pa.

"Lidgerwood Hoisting Engines, Direct Current, 250 and 500 Volts," is the title of an eight-page bulletin recently issued by the Lidgerwood Mfg. Co., of New York. This pamphlet is of special interest because it illustrates the great changes which have taken place in the form and arrangement of electric hoists since electric motors were first adopted for hoisting work. In producing the earlier styles of electric hoists the manufacturer was obliged to use such motors as the market afforded that were adapted to the work. The only motors available at that time, however, were made in such a form that to apply them to hoisting work required that the hoisting drums and their operating portions should be radically changed in their relative positions. Instead of having the gears and brake-bands at the left and the friction nut at the right, as had been demonstrated to be handiest through years of experience in building steam hoists, the drums were turned around with the gears to the right and friction nuts to the left. Recognizing that this was not as it should be, the Lidgerwood Company arranged for the redesign of their entire line of electric hoists, ranging from 1½ to 50 HP. These hoists now have the controller handles, friction levers and foot brakes in precisely the same positions as are their equivalent parts on steam hoists for similar work, and an engineer used to steam work can operate them without having to learn the machine over again and with the facility of an old operator.

A CONVENIENT DOTTING PEN.

Architects, engineers and draftsmen will find an ingenious time and labor-saving device in the Ruehle Dotting Pen. Two of the chief advantages which it has over other pens of the



same type lie in the uniform feed of the pink to the dotting wheel, blotting being thereby prevented, and in the fact that the feed of ink is the same as in an ordinary ruling pen. The pen possesses additional merit in that it can be attached to any compasses, and that special dotting wheels of any thickness may be used. The pen is manufactured by E. G. Ruehle & Co., 119 Fulton street, New York.

The Meade Testing Laboratories, Nazareth, Pa., have been established for the inspection and testing of cement. The equipment of the laboratories is of the most improved form, and is designed to carry out the standard tests of the Am. Soc. C. E., as well as any special tests desired by engineers and architects. Richard K. Meade, the Director, is one of the

foremost chemists in the country and a recognized authority on Portland cement. The clients of the laboratory will at all times have the benefit of his knowledge and advice. Clarence E. Kline, the Engineer of Tests, has had much experience in the testing of cement, and all the work undertaken by the laboratories will be placed in expert hands. The laboratories will also make a specialty of the inspection of cement at the mill.

A PERMANENT CONCRETE EXHIBITION.

The Concrete Association of America, composed of men who are engaged in developing the correct use of concrete, has recently opened a permanent exhibition of concrete and cement products at the Brunswick Building, Fifth Avenue and 27th Street, New York. The primary purpose of this exhibition is to show the architect, the builder and the owner who may have certain prejudices against the use of concrete in any but mass work, that the artistic and scientific treatment of the material has reached such a stage that it is not only safe and economical, but that it can be made beautiful. Particularly is the purpose of the show to demonstrate to the incredulous architect that he can build out of concrete, structures which will suit the most esthetic taste. The exhibit comprises many model buildings and sections of buildings, portions of columns and beams, examples of surface finish and parts of cement laboratories. A permanent secretary is in attendance and will be glad to assist visitors in gaining any information not evident from the exhibits.

A. S. M. E. MONTHLY MEETING.

The next monthly meeting of the American Society of Mechanical Engineers will be held Tuesday evening, Jan. 14, in Assembly Room No. 1, of the Engineering Societies Building, at 29 West 39th St., New York. The subject will be "Car Lighting," the presentation being made by Mr. R. M. Dixon, President of the Safety Car Heating and Lighting Company, and will treat of the general subject of light of trains, showing relative economies in the several systems, electric and gas. There will be in operation exhibits of different methods such as the Pintsch mantel, the vapor mantel system, a new acetylene system, and several varieties of axle lighting by electricity with their regulating and governing mechanism. Each member may bring one friend.

TRADE PUBLICATIONS.

CABLEWAYS FOR ALL PURPOSES.—The New York Cableway & Engineering Co., New York City. 5 × 8 ins.; pp. 8; illustrated.

This folder gives a diagram illustrating the cableway manufactured by the company and describes its character briefly, pointing out the advantages it is said to possess over other types.

WATERPROOFERS AND PRESERVATIVES —George Callahan & Co., New York City. Paper; 3½ × 9 ins.; pp. 8.

This folder contains a description of the methods used to repair and preserve roofs of all kinds with the Rubber Roof Cement and the Elastica Roof Coating. These compounds are manufactured by George Callahan & Co., and are used for repairing tin, iron, steel, felt, wood, slate and paper roofs, as well as in many underground structures.

MOORE VACUUM-TUBE LIGHT.—Moore Electrical Co., Newark, N. J. Paper; 3½ × 5 ins.; pp. 4; illustrated.

This is a small folder setting forth some of the advantages claimed for the vacuum-tube system of indoor illumination, the scientific features of which were set forth on page 264 of this magazine for October. It is stated in the folder that there are business places (20 × 60 ft.) in which the installation of Moore tubes has saved $40 per month over the forms of illumination previously used.

THE BERGEN POINT IRON WORKS.—Bergen Point Iron Works, Bayonne, N. J. Paper; 6 × 9 ins.; pp. 50; illustrated.

In this catalogue a few of the typical machines and appliances constructed under the patents controlled by the Bergen Point Iron Works are illustrated, and some of the ways in which these devices serve as labor savers are suggested. Rope dumpers, wheelbarrow tubs, the company's patent cars, and many other appliances of like character are among the machines described in it.

THE BARRETT HAND-BOOK.—The Barrett Manufacturing Co., New York. Paper; 4½ × 8 ins.; pp. 48; illustrated.

This booklet contains a description of the roofings of the Barrett Co., manufactured according to the Barrett specification. This calls for a five-ply coal tar pitch, felt and slag or gravel roofing, put on in such manner as to make it of the highest efficiency. Interesting illustrations of the fire-retardent qualities of this roofing are given. The booklet also con-

tains descriptions of the Barrett waterproofing for cellars, foundation walls and underground structures in general.

THE CLIMAX TRACK DRILL.—Cook's Standard Tool Co., Kalamazoo, Mich. Paper; 6 × 9 ins.; pp. 16; illustrated.

This pamphlet describes the Climax drill and the advantages obtained by its use. One feature which recommends it especially is the fact that it is made of the finest crucible steel and will stand up under the very hard usage to which every track drill is subjected. Other track appliances, such as track tool grinders, steel and wood-steel cattle guards and single and double acting trip and lowering jacks, are also described in the booklet.

A STORAGE BATTERY IN A LARGE STEEL WORKS.—Bulletin No. 8. The General Storage Battery Co., 42 Broadway, New York. Paper; 8 × 10½ ins.; pp. 8; illustrated.

This bulletin describes the floating or "line" battery of the Cambria Steel Co., which is in use in their plant at Johnstown, Pa. The battery consists of 106 cells of the General Storage Battery Co.'s regular "Bijur High-Duty" type, having a capacity of 2,400 amperes for 20 minutes. As a result of its installation the Cambria Steel Co. has saved in initial cost over generating equipment of the equivalent capacity and in other directions and also created a reserve source of supply.

ELECTRIC PYROMETERS.—Catalogue No. 17. William H. Bristol, New York City. Paper; 9 × 12 ins.; pp. 44; illustrated.

This handsome catalogue describes the William H. Bristol electric pyrometers for indicating, recording and controlling high temperatures. These pyrometers are designed for practical use in a number of processes where accurate measurement and control are essential. A number of improvements over other types have already brought them into wide use in the industries, although the earliest patent under which they are manufactured is dated July 5, 1904.

THE UNIT SYSTEM OF RIGID REINFORCEMENT.—Containing a Discussion of the Necessity for Greater Accuracy in Concrete Construction. By Ross M. Tucker, M. Am. Soc. C. E. Tucker & Vinton, New York City. Paper; 4¾ × 7 ins.; pp. 32; illustrated.

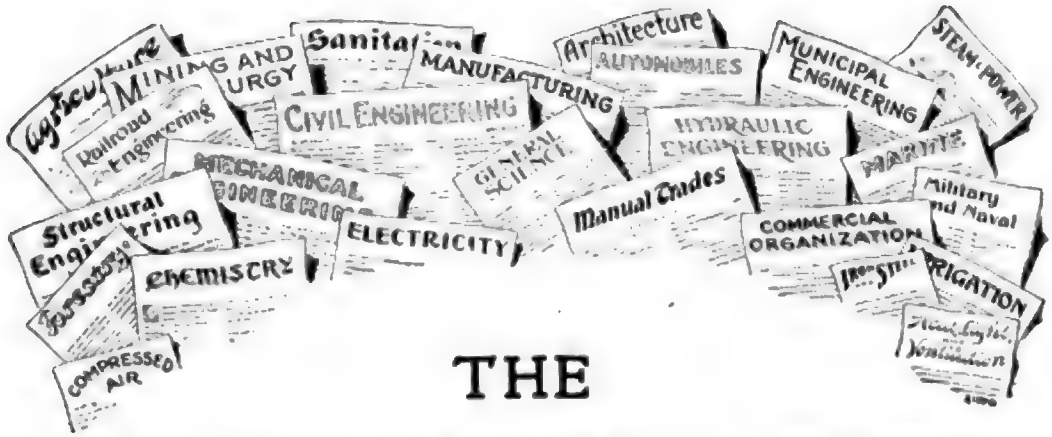
The "Unit System" as used by the Tucker & Vinton Corporation is herein described and the advantages which it possesses over those systems which use disconnected reinforcing rods are shown. There is also a short but interesting and convincing argument on the advantages of the "Cost-Plus-a-Premium" contract, which is the only system under which the Tucker and Vinton Corporation will estimate on or accept any work.

STEEL TAPES, RULES, GAGES, ETC.—James Chesterman & Co., Ltd., Sheffield, England. Paper; 5½ × 8½ ins.; pp. 60; illustrated.

This catalogue contains particulars regarding the numerous forms of measuring appliances made by this firm, among them being patent measuring tapes, land chains, band chains, steel rules and straight edges, T-squares, scales, and other tools for engineers. One specialty described is a patented steel jointed rule, 2 ft. long, machine-divided, for measuring or setting out angles to any degree. This rule has an accurate scale of chords engraved on one side, from 0° to 120°, advancing by half degrees, and is also provided with two center dots, one on each blade, by which, with the aid of a pair of dividers, the rule can be set to any desired angle, or, vice versa, any angle can be determined. The American agents for this house are Wiebusch & Hilger, 9-15 Murray St., New York.

THE TREATMENT OF BELTS AND ROPES FOR SERVICE AND PROFIT.—Published by the Cling-Surface Co., Buffalo, N. Y. Paper; 4⅛ × 7 ins.; pp. 87; illustrated.

In this pamphlet the Cling-Surface Company presents a large array of facts to show that belts treated with Cling-Surface will last through a much longer period of service, and at the same time will be productive of a decided saving in horse-power. By the use of this preparation on belts and ropes used for the transmission of power, slipping is said to be entirely prevented. This permits the running of belts with a greatly decreased tension upon them, and the loss from friction between the belt and pulley is thereby reduced to a minimum. The pamphlet contains several interesting statements of the results of experiments made comparing belts treated with Cling-Surface and ordinary belts. The tests showed a very high efficiency of power transmission when slack treated belts were used and a decided all around superiority to the untreated belts. It is said that belts treated with this preparation do not become charged with static electricity in the winter, thus rendering various devices to obviate this tendency in ordinary belts unnecessary. The manufacturer who uses belts and ropes for power transmission will find considerable matter of interest in this pamphlet.



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This Index is intended to cover the field of technical literature in a manner that will make it of the greatest use to the greatest number—that is, it will endeavor to list all the articles and comment of technical value appearing in current periodicals. Its arrangement has been made with the view to its adaptability for a card-index, which engineers, architects and other technical men are gradually coming to consider as an indispensable adjunct of their offices.

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The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

In order to comply with the many suggestions and requests of readers who desire to make practical use of this index, it is printed on one side of the sheet only, to permit the clipping of any desired items.

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JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

Journal Am. Foundrymen's Assn.
Journal Assoc. Engineering Societies.
Journal Eng. Soc. of Western Pa.
Journal Franklin Institute.
Journal West. Society of Engineers.
Proceedings Am. Soc. C. E.
Proceedings Can. Soc. C. E.
Proceedings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
Proceedings Pacific Coast Ry. Club.
Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
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American Exporter.
American Gas Light Journal.
American Industries.
American Inventor.
American Journal of Science.
American Machinist.
American Shipbuilder.
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Architectural Record.
Architectural Review.
Architects' and Builders' Mag.
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Bulletin Am. Iron & Steel Assn.
Bulletin of Dept. of Labor.
Bulletin Univ. of Kansas.
Bulletin Univ. of Wisconsin.
California Journal of Technology.
Canadian Architect and Builder.
Canadian Cement & Concrete Review.
Canadian Electrical News.
Canadian Engineer.
Canadian Machinery & Manufacturing News.
Canadian Manufacturer.
Canadian Mining Journal.
Canadian Municipal Journal.—See Adv. opposite.
Carpentry and Building.
Cassier's Magazine.
Castings.
Cement.
Cement Age.
Cement and Engineering News.
Cement Era.
Central Station.
Chemical Engineer.
Cold Storage and Ice Trade Journal.
Commercial America.
Compressed Air.—See Adv. opposite.
Concrete.
Concrete Age.
Concrete Engineering.
Contractor.
Cornell Civil Engineer.
Daily Consular and Trade Reports.
Domestic Engineering.
Economic Geology.
Electrical Age.
Electrical Review.
Electric Journal.
Electric Railway Review.—See Adv. opposite.
Electrical World.
Electric Traction Weekly.
Electrochemical and Metallurgical Industry.
Engineer.
Engineering-Contracting.—See Adv. opposite.
Engineering and Mining Journal.
Engineering Magazine.
Engineering News.—See Adv. opposite.
Engineering Record.
Far Eastern Review.
Fire and Water Engineering.
Forestry and Irrigation.
Foundry.
Gas Engine.
Glass and Pottery World.
Hardware.
Heating and Ventilating Magazine.
Horseless Age.
Ice and Refrigeration.
Illuminating Engineer.
Implement Age.
Industrial Magazine.—See Adv. opposite.
Industrial World.
Inland Architect.
Insurance Engineering.
International Marine Engineering.
Iron Age.—See Adv. opposite.
Iron Trade Review.
Irrigation Age.
Journal of Electricity, Power and Gas.
Journal of U. S. Artillery.
Journal of Worcester Polytechnic Institute
Judicious Advertising.
Machinery.
Marine Review.
Metal Industry.
Metal Worker, Plumber and Steam Fitter.
Mines and Minerals.
Mining and Scientific Press.
Mining Science.
Mining World.
Modern Machinery.
Moody's Magazine.
Motor.
Motor Age.
Motor Boat.
Motor Car.
Motor Traffic.
Municipal Engineering.
Municipal Journal and Engineer.
Paper Trade Journal.
Plumber's Trade Journal.
Popular Mechanics.
Popular Science Monthly.
Power.
Power and Transmission.
Power Wagon.
Practical Engineer.
Printers' Ink.
Profitable Advertising.
Progressive Age.—See Adv. opposite.
Railroad Gazette.
Railway Age.—See Adv. opposite.
Railway and Engineering Review.
Railway and Locomotive Engineering.
Railway and Marine World.
Railway Engineering.
Railway Master Mechanic.
Roadmaster and Foreman.—See Adv. opposite.
Rose Technic.
Scientific American.
Scientific American Supplement.
Selling Magazine.
Sibley Journal of Engineering.
Southern Machinery.
Stevens Institute Indicator.

Stone.
Street Railway Journal.
Technical World Magazine.
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Tradesman.
Waterproofing.
Western Electrician.
Wood Craft.
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Annales des Ponts et Chaussées. (m.) Paris.
Beton und Eisen. (q.) Vienna.
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Deutsche Bauzeitung. (b-w.) Berlin.
Dingler's Polytechnic Journal. (w.) Berlin.
Eisenbahntechnische Zeitschrift. (b-m.) Berlin.
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Elektrochemische Zeitschrift. (m.) Berlin.
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Zeitschrift d. Oest. Ing. und Arch. Ver. (w.) Vienna.
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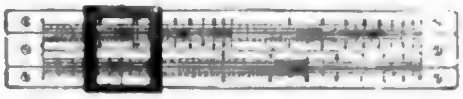

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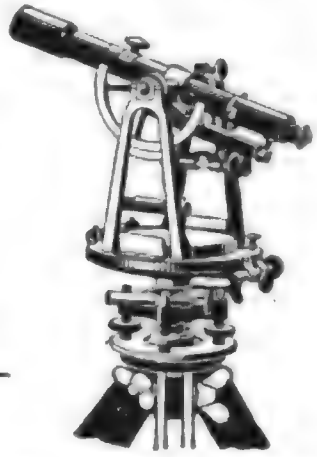

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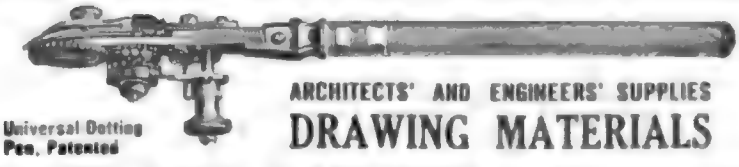

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French Automobile Situation.

The Automobile Situation in France. Jacques Boyer. Cassier's Mag—Dec., 07. 15 figs. 3400 w. 40c.

Motor Car.

Engine of Steam Motor-Car. Engg—Nov. 29, 07. 8 figs. 900 w. 40c. Describes a new type of steam motor for use in automobiles.

CIVIL ENGINEERING

BRIDGES.

Arch Design.

Empiricism and Error in Arch Design. Charles M. Comstock. Eng News—Nov. 28, 07. 3500 w. 20c.

Bridge Approaches.

Curved Girder Approach Viaduct of the Austerlitz Bridge over the Seine. L. Biette. Génie Civil.—Dec. 7, 07. 24 figs. 3500 w. 60c.

The Queens Approach to the Blackwell's Island Bridge, New York. Eng Rec—Dec. 7, 07. 8 figs. 3600 w. 20c.

Concrete Bridge.

Concrete Bridge 1,200 Feet Long. Cem Era—Dec., 07. 3 figs. 1600 w. 20c. Describes the 12-span bridge over the Maumee River, near Waterville, Ohio.

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Quebec Bridge.

The Phoenixville Testimony in the Quebec Bridge Inquiry. Eng News—Nov. 28, 07. 2500 w. 20c. Gives copious extracts from the testimony of the president, manager, chief inspector and engineers of the company.

Stresses in Bridge Members.

The Breaking Strength of Latticed Bridge Members. L. Orandtl. Z V D I—Nov. 23, 07. 2000 w. 60c.

Working-Stresses in Steel Construction. C. A. P. Turner. Eng News—Dec. 12, 07. 4300 w. 20c. Discusses some features of general specifications and their applicability to structures of extraordinary size.

Viaducts.

Reinforced Concrete Viaduct on the Richmond and Chesapeake Bay Railway, Richmond, Va. Eng News—Dec. 12, 07. 11 figs. 1300 w. 20c.

The Woodbury Viaduct. Eng Rec—Dec. 14, 07. 6 figs. 1900 w. 20c. Describes the double-track plate-girder viaduct of the Erie & Jersey R. R. at Woodbury, N. J., having a height of about 72 feet and a length of 590 feet between face walls of approaches.

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Dump Cars of Large Capacity for Construction Work. Eng News—Dec. 12, 07. 1 fig. 1000 w. 20c. Describes cars of 12 to 18 cu. yds. capacity which are dumped by compressed-air apparatus.

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Method and Cost of Loading Dump Wagons from an Ingeniously Designed Hopper or Table. J. C. Black. Engg-Contr—Dec. 11, 07. 5 figs. 5100 w. 20c.

Railway Embankments.

Cost of Making Railway Embankments with Wheelbarrows, Showing the Economy of Piece-Work. Wilmer Waldo. Engg-Contr—Dec. 4, 07. 1200 w. 20c.

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Can Earthquake-Proof Buildings be Erected? L. J. Mensch. Arch & Engr of Cal—Nov., 07. 2300 w. 40c. Paper read before the San Francisco Chapter, A. I. A.

Data on Terra-Cotta Brick Fireproofing. Engg-Contr—Dec. 4, 07. 700 w. 20c.

Fireproof Construction.—II. M. M. Sloan. Arch & Bldrs Mag—Nov., 07. 8 figs. 3600 w. 40c.

Fire Protection System of the American Dock Stores. Frank Sutton. Eng Rec—Dec. 7, 07. 3 figs. 2400 w. 20.

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Air Strainers

Air Separators

Air Traps

Air Pressure Regulators

Air Pressure Governors

Air Pressure Indicators

Air Pressure Recorders

Air Pressure Alarms

Air Pressure Switches

Air Pressure Relief Valves

Air Pressure Safety Valves

Air Pressure Check Valves

Air Pressure Stop Valves

Air Pressure Gate Valves

Air Pressure Globe Valves

Air Pressure Angle Valves

Air Pressure Three-way Valves

Air Pressure Four-way Valves

Air Pressure Five-way Valves

Air Pressure Six-way Valves

Air Pressure Seven-way Valves

Air Pressure Eight-way Valves

Air Pressure Nine-way Valves

Air Pressure Ten-way Valves

Air Pressure Eleven-way Valves

Air Pressure Twelve-way Valves

Air Pressure Thirteen-way Valves

Air Pressure Fourteen-way Valves

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Air Pressure Thirty-six-way Valves

Air Pressure Thirty-seven-way Valves

Air Pressure Thirty-eight-way Valves

Air Pressure Thirty-nine-way Valves

Air Pressure Forty-way Valves

Air Pressure Forty-one-way Valves

Air Pressure Forty-two-way Valves

Air Pressure Forty-three-way Valves

Air Pressure Forty-four-way Valves

Air Pressure Forty-five-way Valves

Air Pressure Forty-six-way Valves

Air Pressure Forty-seven-way Valves

Air Pressure Forty-eight-way Valves

Air Pressure Forty-nine-way Valves

Air Pressure Fifty-way Valves

Air Pressure Fifty-one-way Valves

Air Pressure Fifty-two-way Valves

Air Pressure Fifty-three-way Valves

Air Pressure Fifty-four-way Valves

Air Pressure Fifty-five-way Valves

Air Pressure Fifty-six-way Valves

Air Pressure Fifty-seven-way Valves

Air Pressure Fifty-eight-way Valves

Air Pressure Fifty-nine-way Valves

Air Pressure Sixty-way Valves

Air Pressure Sixty-one-way Valves

Air Pressure Sixty-two-way Valves

Air Pressure Sixty-three-way Valves

Air Pressure Sixty-four-way Valves

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Air Pressure Sixty-six-way Valves

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Air Pressure Sixty-eight-way Valves

Air Pressure Sixty-nine-way Valves

Air Pressure Seventy-way Valves

Air Pressure Seventy-one-way Valves

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The Design of 75-ft. Reinforced-Concrete Girders for the Mammoth Garage, White Plains, New York. C. E. Tirrell. Eng News—Dec. 12, 07. 8 figs. 5500 w. 20c. Gives detail drawings and calculations for flexure.

The Franco-British Exhibition of 1908. Engg—Nov. 29, 07. 29 figs. 1200 w; Dec. 6, 3 figs, 800 w. Each 40c. Describes the construction of the Machinery Hall and the Stadium for the Olympian games.

The New York Public Library. Am Arch—Nov. 23, 07. 25 figs. 1400 w. 60c.

Two New Record-Breaking Office Buildings in New York City. Eng News—Dec. 5, 07. 16 figs. 5300 w. 20c. Gives details of the construction of the Singer and City Investment Buildings.

Underground Railway Station with Reinforced-Concrete Arched Roof. H. Lossier. Beton u Eisen—Nov., 07. 11 figs. 3000 w. $1.

Caisson Disease.

The Cause, Treatment and Prevention of the "Bends," as Observed in Caisson Disease. Prof. J. R. Macleod. Jl Assn Engg Socs.—Nov., 07. 11000 w. 60c. Paper read before the Civil Engineers' Club of Cleveland, May 14, 07.

Cement Pipes.

Cost of Molding and Method of Testing Small Cement Pipes. Engg-Contr—Dec. 4, 07. 1 fig. 2300 w. 20c. Abstract from a paper by Albert Eugene Wright, in the California Journal of Technology for Oct., 07.

Conduits.

Methods of Laying Conduit Systems. Engg-Contr—Dec. 4, 07. 5 figs. 1900 w. 20c.

Corrugated Sheeting.

The Strength of Corrugated Sheeting. Eng News—Dec. 12, 07. 900 w. 20c.

Dams.

Methods and Cost of Making Two Hydraulic Fill Dams. Engg-Contr—Nov. 13, 07. 3 figs. 3200 w. 20c.

The Urf Dam and Hydro-Electric Power Distribution. Engg—Nov. 29, 07. 1 fig. 4500 w. 40c. Describes the dam of the second largest reservoir in Europe—in Rhenish Prussia.

Pipe Line for Oil.

Rifled Pipe Line for Conveying Oil on the Southern Pacific. Ry Age—Dec. 13, 07. 6 figs. 3200 w. 20c. Describes the use of an 8-inch rifled pipe which overcame difficulties previously experienced in pumping.

Reinforced-Concrete Construction.

A Few Tests and Experiments with Reinforced concrete. R. T. Surtees. Eng Rec—Dec. 14, 07. 16 figs. 3600 w. 20c. Gives results of tests on various mixtures and also destructive tests of reinforced-concrete columns.

Artistic Expression of Steel and Concrete. C. Howard Walker. Cem Era—Dec., 07. 3300 w. 20c. Read before the Forty-first Annual Convention of the American Institute of Architects, Chicago, Nov. 18-20, 07.

Faults of Reinforced-Concrete Design and Construction. H. F. Porter. Engg-Contr—Nov. 13, 07. 2600 w. 20c.

Reinforced Concrete: Some Simple Formulas and Tables.—IV. Ernest McCullough. Cem Era—Dec., 07. 4400 w. 20c.

Reinforced Concrete Beams. Eng Rec—Dec. 14, 07. 2 figs. 400 w. 20c. Gives diagram for the design of beams used on U. S. Reclamation Service Work.

Reinforced-Concrete Building Laws: their Differences and Deficiencies. H. C. Hutchins. Eng Mag—Dec., 07. 15 figs. 5800 w. 40c. Gives the laws of various cities, comparing them to point out the need of a standard building code, which should be adopted by all cities.

The Design and Cost of Reinforced-Concrete Floors of Substructures. Waterproofing—Dec., 07. 1 fig. 900 w. 20c. Discusses the economical use of reinforced concrete to resist water pressure occurring in cellars and other substructures situated below the ground-water level.

The Vierendeel System of Reinforced-Concrete Girders for Long Spans. F. Gebauer. Beton u Eisen—Nov., 07. 5 figs. 2500 w. $1. Continued.

Reservoirs, Prevention of Seepage in.

Lining Ditches and Reservoirs to Prevent Seepage Losses. Eng News—Dec. 5, 07. 1 fig. 2800 w. 20c.

Riveted Joints.

An Investigation of Some of the Commoner Defects in Riveted Work upon the Strength of Joints. J. C. Black. Cal Jl of Tech—Nov., 07. 15 figs. 3000 w. 20c. Gives results of experiments, some of which are contrary to generally accepted practice.

Roofs.

A Light Roof Girder System in a Reinforced-Concrete Garage. Eng News—Dec. 12, 07. 5 figs. 3200 w. 20c. Gives details of roof system containing girders of very bold design.

Roofs.—V. Ry Engr—Dec., 07. 5 figs. 2300 w. 40c. Considers a few cases of ambiguity and of irregular or unsymmetrical loading, working them out by graphical methods.

Sewer (Reinforced Concrete).

A Large Reinforced-Concrete Sewer in the Borough of Queens, New York City. Eng Rec—Nov. 30, 07. 6 figs. 2500 w. 20c. Describes a circular reinforced-concrete trunk sewer, varying from 2½ to 15 ft. in diameter, to serve a 2,150-acre area.

Smoke Stack and Water Tower.

Combined Smoke Stack and Water Tower. C. Luetty. Beton u Eisen—Nov., 07. 6 figs. 500 w. $1. Describes a reinforced-concrete structure in Shanghai, built according to the Intz system.

The Queries & Answers

Column is open to Subscribers only, and Queries cannot be inserted unless accompanied by the Name and Address of the Subscriber forwarding them. Queries should be written on one side of the paper only, and should be clear and concise. Answers to Queries should be addressed to the Editor, and not to the Publishers.

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Method of Mixing and Placing Concrete for a Tunnel Lining. Engg-Contr—Dec. 11, 07. 5 figs. 1400 w. 20c.

The Commercial Aspects of Present and Proposed Alpine Railway Tunnels. Eng News—Dec. 5, 07. 1 fig. 6000 w. 20c.

The Italian Approaches to the Simplon Tunnel. Engg—Nov. 22, 07. 24 figs. 3300 w. 40c.

The Loetschberg Tunnel and its Relation to Alpine Railway Routes. Eng News—Dec. 5, 07. 2 figs. 3900 w. 20c.

The Tunnel and River Shaft of the Detroit Water Works. James Ritchie. Jl Assn Engg Socs.—Nov., 07. 2700 w. 60c. Paper read before the Civil Engineers' Club of Cleveland, May 14, 07.

Tunneling with Telescopic Tubes. Engg-Contr—Nov. 13, 07. 300 w. 20c.

A Few Points of the Waterproofing of Superstructures. Neal Farnham. Waterproofing—Nov., 07. 1200 w. 20c.

MATERIALS.

Cement and Concrete.

Efficiency of Cement Joints in Joining Old Concrete to New. Eng News—Dec. 12, 07. 1 fig. 900 w. 20c. Gives results of French experiments, showing the value of a cement wash in joining new concrete to old.

Portland Cement. H. K. Bamber. Engg—Nov. 29, 07. 1600 w. 40c. A communication criticizing the revised British standard specifications of Portland cement.

The Modern Manufacture of Portland Cement.—I. British Clay Wkr—Nov., 07. 4 figs. 1000 w. 40c.

Rust Prevention.

Rust Prevention.—II. L. M. Stern. Ir Age—Nov. 28, 07. 1 fig. 5500 w. 20c.

Steel.

Breaking Tests of Nicked Bars.—I. Herr Ehrenberger. Z V D I—Dec. 14, 07. 4 figs. 3000 w. 60c. Describes tests on carbon and alloy steels by means of a pendulum hammer testing machine.

New Special Structural Shapes. Ry Age—Nov. 29, 07. 4 figs. 1600 w. 20c. Describes new steel beam sections, known as the Bethlehem Steel Co. beams, which have wider flanges and a lesser proportion of material in the web than the American standard beams.

Specification for Iron and Steel. Dr. Richard Moldenke. Ir Tr Rev—Dec. 5, 07. 2300 w. 20c. A paper presented at the New York (Dec., 07) meeting of the American Society of Mechanical Engineers.

Timber, Preservative Treatment of.

Preservative Treatment of Poles by the Open-Tank Process. D. A. Rockwell. El Wld—Dec. 14, 07. 2100 w. 20c.

The Life and Preservation of Pitch-Pine Fence Posts. Eng News—Dec. 12, 07. 1200 w. 20c. Abstract from Bulletin No. 75, of the Wyoming Experiment Station.

The Treatment of Fence Posts to Increase Durability. Hugh P. Baker. Waterproofing—Nov., 07. 6 figs. 20c.

RIVERS, CANALS, HARBORS.

Canal Locks.

Locks and Inclined Railways for Canals. H. Bertschinger. Z V D I—Dec. 7, 07. 33 figs. 5000 w. Dec. 14, 4 figs., 1500 w. Each 60c. Discusses the utility and efficiency of various methods of transferring canal boats from one level to another.

The Ship-Lift on the Dortmund-Ems Canal. R. R. Gaz—Dec. 6, 07. 4 figs. 800 w. 20c.

Coal-Storage Wharf.

A Large Coal-Storage Wharf at Superior, Wisconsin. Eng Rec—Nov. 30, 07. 5 figs. 2600 w. 20c.

Dredge.

Hydraulic Dredge Used on the New York State Barge Canal. Emile Low. Eng News—Dec. 5, 07. 3 figs. 1800 w. 20c.

Floating Dock.

Floating Dock at Rotterdam. Engr (Lond)—Dec. 6, 07. 5 figs. 1100 w. 40c.

Harbor Works, Dover.

The Harbor Works at Dover, England. C. O. Burge. Eng Rec—Dec. 14, 07. 1 fig. 1400 w. 20c.

Land Reclamation.

Land Reclamation in Holland.—II. Engr—Nov. 29, 07. 2300 w. 40c.

Method and Cost of Surveying and Reclaiming Wet Farm Land. Engg-Contr—Dec. 4, 07. 4 figs. 3200 w. 20c.

Ore Dock.

First Steel Ore Dock on the Great Lakes. Ir Tr Rev—Nov. 28, 07. 5 figs. 2400 w. 20c. Describes dock being built by the United States Steel Corporation at Two Harbors, Minn.

Panama Canal.

Annual Report of the Isthmian Canal Commission to the Secretary of War. Eng News—Nov. 28, 07. 5 figs. 10,000 w. 20c. A reprint of those parts of interest to engineers.

Conditions Along the Panama Canal. Eng Rec—Nov. 30, 07. 6 figs. 6500 w. 20c.

Pier.

Concrete Construction at Jamestown. Percy H. Wilson. Cem Age—Dec., 07. 9 figs. 2300 w. 20c. Describes two permanent structures: the Government Pier and the History Building.

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The Place of the Laboratory in the Training of Engineers. Prof. A. L. Mellanby. Mech Eng—Nov. 23, 07. 5 figs. 2800 w. 40c. Read before the Institution of Engineers and Shipbuilders in Scotland, Nov. 19, 07.

Factory Management.

Economic Considerations in the Management of Plant. W. H. Patchell. Engg—Nov. 22, 07. 5600 w. 40c. Address of the president, November 13, 07, before the Association of Engineers-in-Charge.

Intensified Production. A. Hawkes. Mech Engr—Dec. 7, 07. 4100 w. 40c. Discusses the practical use of factory accounts.

Profit-Making in Shop and Factory Management. C. U. Carpenter. Eng Mag—Dec., 07. 2600 w. 40c. X.—Effective Organization in the Executive Management.

Filing and Indexing Data.

Filing and Indexing Useful Data. G. W. Lee, Librarian Stone & Webster. Elec Trac Wkly—Nov. 28, 07. 7 figs. 1300 w. 20c.

Industrial Education.

A Rising Industrial Problem: The New Apprenticeship. George Stratton. Eng Mag—Dec., 07. 6900 w. 40c.

How Shall We Train Boys Who Are to Become Machinists? W. L. Hardy. Am Mach—Dec. 12, 07. 900 w. 20c.

Rational Trades Instruction. O. M. Becker. Cassier's Mag—Dec., 07. 14 figs. 4100 w. 40c.

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The Infringement of Patents. John Edson Brady. Elec Wld—Dec. 7, 07. 2800 w. 20c.

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A Discussion of Smoke Prevention. Eng Rec—Dec. 14, 07. 2700 w. 20c. Report of committee of the Chamber of Commerce of Syracuse, N. Y.

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Representation of Armature Reaction of the Synchronous Motor as an Equivalent Reactance. A. S. Langsdorf. El Wld. 4 figs. 1500 w. 20.

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The Dielectric Strength of Insulating Materials and the Grading of Cables. Alexander Russell. El Engr—Nov. 22, 07. 2300 w. 40c.

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Energy Transformations from the Electrical Engineer's Standpoint.—I. H. M. Hobart. Elec Rev—Dec. 14, 07. 2 figs. 800 w. 20c.

Leakage of Induction Motors.

The Leakage of Induction Motors.—I. R. Goldschmidt. Elecn—Nov. 25, 07. 13 figs. 5000 w. 40c. Describes methods for calculations of no-load current and leakage in induction motors.

Manganin Resistances.

The Variation of Manganin Resistances with Atmospheric Humidity. E. B. Rosa. Elecn—Nov. 15, 07. 4000 w. 40c. Maintains, as against recent arguments, that these variations are of importance.

Resonance.

Resources in Alternating Current Circuits. F. Grünbaum. Elek Zeit—Nov. 21, 07. 4 figs. 5000 w. 40c. Discusses mathematically the conditions for various causes of resonance.

Spark Coils.

The Design and Operation of Spark Coils. F. W. Springer. El Wld—Dec. 14, 07. 9 figs. 7000 w. 20c.

Transient Electric Phenomena.

Transient Electric Phenomena.—I. C. P. Steinmetz. Gen Elec Rev—Dec., 07. 5 figs. 4500 w. 20c.

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Motors.

Characteristics of Electric Motors. E. H. Anderson. Am Mach—Dec. 12, 07. 1 fig. 2500 w. 20c. Shows how the work to be done determines a motor's continuous and intermittent capacity and its design and rating.

Direct-Current Motors, Their Action and Control. F. B. Crocker and M. Arendt. Elec Wld—Dec. 7, 07. 2600 w. 20c. II. —Shunt motor problems.

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The Rosenberg Generator. B. M. Eoff. Gen Elec Rev—Dec., 07. 13 figs. 3000 w. 20c. Describes a dynamo which delivers a constant current at variable speed, and a constant output at constant speed.

Turbo-Generators.

The Development of Turbo-Generators. Dr. Robert Pohl. Elec Engr—Nov. 29, 07. 1 fig. 1300 w. Dec. 6, 5 figs., 2500 w. Each, 40c. Paper read before the Institution of Electrical Engineers.

The Year's Progress in the Design of Electric Generators for Direct Connection to Steam Turbines. H. M. Hobart. Elec Engg—Dec. 5, 07. 17 figs. 2300 w. 40c.

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Wiring for Direct-Current and Alternating-Current Motors. Louis J. Auerbacher. Elec Wld—Dec. 7, 07. 10 figs. 2500 w. 20c.

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Distribution of Light. Otto Foell. Trans Ill Engg Soc—Nov., 07. 4 figs. 3500 w. 80c. Read before the Pittsburg Section of the Illuminating Engineering Society.

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A New Flame Arc Lamp. Engr (Lond)—Dec. 6, 07. 3 figs. 800 w. 40c. Describes the novel features of the Crompton-Blondell lamp.

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Comparison of Glow Lamp Standards of Different Countries. Elec Engg (Lond)—Dec. 5, 07. 900 w. 40c.

The present Status of the Carbon and Metallic Filament Incandescent Lamps. J. M. Robertson. Can Elec News—Nov., 07. 5 figs. 4300 w. 20c. Paper read at the Annual Convention of the Canadian Electrical Association.

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Lighting of a Large Retail Store. Frederick J. Pearson. Elec Rev—Dec. 7, 07. 10 figs. 4700 w. 20c. A paper read before the Chicago Section of the Illuminating Engineering Society, Oct. 10, 07.

Light and Power in the Commercial National Bank Building. W Elecn—Dec. 7, 07. 3 figs. 2000 w. 20c.

Plain Talks on Illuminating Engineering. E. L. Elliott. Illum Engr—Dec., 07. 3 figs. 2700 w. 20c. XIII.—Residence Lighting.

Mercury Vapor Lamp.

A New Form of Cooper-Hewitt Mercury Vapor Lamp. F. H. von Keller. Jl of the Frank Inst—Dec., 07. 5 figs. 3600 w. 60c. Paper read before the Franklin Institute, Oct. 16, 07. Describes a lamp differing from other types, principally in its structure and the means for starting the arc in the lamp.

Nernst Lamp.

The Value of the Nernst Lamp to Central Stations. A. E. Fleming. Can Elec News—Nov., 07. 3000 w. 20c. Paper read at the Annual Convention of the Canadian Electrical Association.

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Curves for the Calculation of Foot Candles. C. W. Kinney. Illum Engr—Dec., 07. 1 fig. 800 w. 20c.

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The Audion.—I. Lee De Forest. Sc Am—Nov. 30, 07. 6 figs. 3800 w. 20c. Describes a new receiver for use in wireless telegraphy.

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Notes on the Testing of Multi-Range Ammeters and Voltmeters and Low-Reading Voltmeters. A. E. Moore. Elec Engr—Nov. 29, 07. 2 figs. 2200 w. 40c.

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Method of Testing Direct-Current Dynamos. E. S. Lincoln. Power—Dec., 07. 7 figs. 2500 w. 40c. Describes method of measuring insulation resistance, locating connections and determining the rating and characteristics of a dynamo.

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A Method of Measuring Dielectric Strength. S. M. Hills and T. Germann. Elec Engr—Nov. 28, 07. 3 figs. 800 w. 40c.

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On a Standard of Mutual Inductance. Albert Campbell. Elecn—Nov. 22, 07. 5 figs. 2000 w. 40c. Abstract of paper read before the Royal Society.

The Use of the Duddell Arc for Inductance and Capacity Measurements. Elec Rev (Lond)—Dec. 6, 07. 3 figs. 800 w. 40c.

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The Magnetic Testing of Iron. W. H. F. Murdoch. Elec Rec (Lond)—Nov. 29, 07. 2 figs. 1600 w. 40c. Abstract of paper read before the Institution of Electrical Engineers at Sheffield, Nov. 25, 07.

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Some Recent Improvements in the Wright Mercury Electrolytic Meter.—I. H. S. Hatfield. Elecn—Dec. 6, 07. 3 figs. 2500 w. 40c.

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The Calculation of Water Resistances for Testing Large Alternators. C. Richter. Elek u Masch—Nov. 17, 07. 6000 w. 60c.

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Notes on Drawing-In Cable. W. Pleasance. Elec Rev (Lond)—Nov. 29, 07. 2 figs. 2200 w. 40c.

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The Municipal Electrical Conduit System of Auburn, N. Y. J. W. Ackerman. Mun Engg—Dec., 07. 3 figs. 1300 w. 40c.

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On the Behavior of Fuse Wires. M. P. Weinbach. Engg Quarterly—Nov., 07. 12 figs. 10,000 w. 80c. Thesis presented for degree, University of Missouri, June, 07.

The Standardization of Edison-Base Fuses by Means of Special Apparatus. R. Hundhausen. Elek Zeit—Nov. 21, 07. 5 figs. 2500 w. 40c.

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Long-Distance Power-Transmission Lines. E. A. Löf. El Rev—Nov. 30, 07. 5 figs. 1400 w. Dec. 7, 4 figs., 1000 w. Each, 20c. Discusses the different factors to be taken in consideration for the proper design of the transmission line.

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Electrical Driving in Textile Factories. H. W. Wilson. Mech Engr—Dec. 7, 07. 6200 w. 40c. Paper presented to the Manchester Section of the Institute of Electrical Engineers.

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The Protection of Buildings from Lightning. Alfred Hands. Elec Engr—Nov. 29, 07. 5 figs. 3800 w. 40c.

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Firing Kilns by Superheated Steam. British Clay Wkr—Nov., 07. 2800 w. 40c.

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A Color Screen Color Meter. Frederick E. Ives. Jl Franklin Inst—Dec., 07. 1000 w. 60c. Paper read before the Franklin Institute, Nov. 7, 07. Describes an instrument for matching, measuring and recording colors used in the arts and industries.

Gas Manufacture.

Accidents in the Manufacturing Gas Industry. Herman Russell. Prog Age—Dec. 2, 07. 11,000 w. 20c. Paper read before the Michigan Gas Association.

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The Distribution of Gas in the Suburbs of Paris. F. Claudet. Génie Civil—Nov. 9, 07. 7 figs. 2500 w. 60c.

Vertical Gas Retorts at Cologne. Prog Age—Dec. 2, 07. 4 figs. 1900 w. 20c. Abstract of a paper read before the German Association of Gas Engineers.

Kaolin.

Mixing and Transporting Kaolin by Hydraulic Process. Engg-Contr—Dec. 11, 07. 1100 w. 20c. Paper read before the Am. Inst. of Mining Engineers.

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The Electric Crane Equipment of the "Lusitania" and the "Mauretania." Elec Eng—Dec. 5, 07. 5 figs. 600 w. 40c.

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The Atlantic Liner "Mauretania." Engr—Dec. 16, 07. 8 figs. 2300 w. 20c. Describes the steam power equipment of this turbine-driven quadruple-screw steamer.

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Who Built the First Steamboat? C. Seymour Bullock. Cassier's Mag—Dec., 07. 9 figs. 4000 w. 40c.

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Notes on Pneumatic Hammers. A. Baril. Rev de Mec—Dec., 07. 30 figs. 12,000 w. $1.80.

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Brass Foundry.

The Brass Foundry. W. S. Quigley. Met Indus—Dec., 07. 1900 w. 20c. Abstract of a paper read before the New York Railroad Club, Nov. 15, 07. Describes modern methods of melting and handling material.

The Jobbing Brass Foundry.—II. J. F. Buchanan. Fndry—Dec., 07. 15 figs. 1600 w. 20c.

Cost System for Jobbing Foundries.

A Uniform Cost System for Jobbing Foundries. James S. Stirling. Ir Age—Dec. 12, 07. 4100 w. 20c. Paper read before the American Foundrymen's Association, Dec. 4, 07, embodying recommendations of the Jobbing Founders' Association.

Fluxes for Soft Metals.

The Choice and Use of Fluxes for Soft Metals. Mech Engr—Dec. 7, 07. 4000 w. 40c. Reprint of article in the "Brass World."

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Erecting Foundry Foundations. J. A. Pratt. Machy—Dec., 07. 12 figs. 3100 w. 40c.

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Report of the Transvaal Commission on the Use of Winding Ropes, Safety Catches and Appliances in Mine Shafts. Eng News—Dec. 5, 07. 8 figs. 7000 w. 20c. Concluded.

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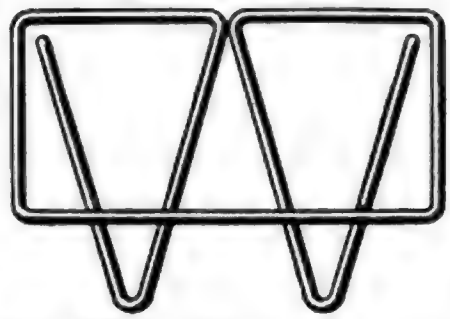

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Pipe Coverings.

A Laboratory Test for Heat Insulating Materials. Charles R. Darling. Engg—Dec. 6, 07. 1 fig. 2300 w. 40c.

The Protection of Steam Pipes from Accident. Arthur Herschmann. Eng Mag—Dec., 07. 7 figs. 2200 w. 40c.

Power-Plant Design.

The Ratio of Heating Surface to Grate Surface as a Factor in Power-Plant Design. W. S. Finlay. Proc Am. Inst. E. E., Nov., 07. 8 figs. 2400 w. 80c. Paper read before the Am. Inst. of E. E., New York, Dec. 13, 07.

Separators.

Value of Separators. T. E. O'Donnell. Engr—Dec. 16, 07. 9 figs. 2000 w. 20c. Discusses the practical value and usefulness of steam separators in all ordinary steam plants.

Steam-Power Plants.

Mechanical Plant of the Brooklyn Institute Building.—I. Eng Rec—Dec. 14, 07. 4 figs. 4400 w. 20c.

New Mechanical Equipment of the Enlarged Tribune Building, New York. Eng Rec—Nov. 30, 07. 2 figs. 5000 w. 20c.

Steam Auxiliary to Hydro-Electric Station. Wm. Lee Church. Elec Wld—Dec. 7, 07. 1 fig. 1700 w. 20c.

The Power Plant of the Commercial National Bank Building. Engr—Dec. 2, 07. 11 figs. 2400 w. 20c. Describes the fire-tube boilers, vertical compound generating units and Corliss pumping engines used.

Steam Turbines.

Design of a 400-Kilowatt Reaction Turbine. Henry F. Schmidt. Engr—Dec 16, 07. 10 figs. 2000 w. 20c. Gives methods utilizing curves which eliminate all mathematical work except the simplest.

Lubrication of Bearings of Steam Turbines. Edward Russell. Power—Dec., 07. 900 w. 40c.

Practical Side of Steam-Turbine Operation. W. J. Kennedy. Power—Dec., 07. 1 fig. 2600 w. 40c. Gives results of three years' experience in a large central station.

Steam-Turbine Construction.—II. T. Franklin. Mech Wld—Nov. 29, 07. 6 figs. 1100 w. 40c.

Supplying Oil to Turbines. Thomas Franklin. Mech Wld—Nov. 22, 07. 4 figs. 1800 w. 20c.

The Dake Steam Turbine. Power—Dec., 07. 8 figs. 700 w. 40c. Describes a turbine in which the steam is made to repeat its action upon the bucket of the same wheel, as in the Riedler-Stumpf type.

The Hamilton-Holzwarth Turbine. Power—Dec., 07. 13 figs. 2000 w. 40c. Describes a new axial-flow action turbine operating under successive stages of steam expansion.

The Zvonicek Steam Turbine. Elek u Masch—Nov. 24, 07. 6 figs. 2000 w. 60c. Describes a new multistage reaction steam turbine.

Superheated Steam Fittings.

Fittings for Superheated Steam. August H. Kruesi. W Elecn—Dec. 7, 07. 2200 w. 20c. Paper read at the annual meeting of the Association of Edison Illuminating Companies at Hot Springs, Va., Sept. 10-12, 07.

MISCELLANEOUS.

Photographing Machinery.

Shop Photography. Machy—Dec., 07. 14 figs. 3200 w. 40c.

METALLURGY

COKE.

Koppers Coke Oven.

The Koppers Coke Oven. Ir Age—Dec. 12, 07. 11 figs. 2500 w. 20c. Describes two types of German coke ovens operated by waste gases and in which the heat is readily controllable.

COPPER.

Classifying Ore with Jigs.

Jigs as Classifiers in Ore Dressing. J. T. Glidden. Eng and Min Jl—Dec. 7, 07. 600 w. 20c.

Refining.

Notes on Copper. A. Humboldt Sexton. Mech Eng—Nov. 23, 07. 3 figs. 4000 w. Dec. 7, 4700 w. Each, 40c. XI.—Refining Copper. XII.—Wet or Leaching Processes.

Smelter Smoke Problem.

Smelter Smoke, with a Discussion on Methods for Lessening its Injurious Effects. L. S. Austin. Min and Sc Pr—Nov. 28, 07 3400 w. 20c.

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Vacuum Separating Process.

The Elmore Vacuum Process at Dolcoath. Edward Walker. Eng and Min Jl—Dec. 14, 07. 5 figs. 2100 w. 20c. Describes the successful separation of the complex tin-copper-tungsten ores of Cornwall, heretofore treated with difficulty.

GOLD.

Cyaniding.

A Cheap Cyanide Plant. Chas. Hunter. Min Wld—Dec. 14, 07. 1000 w. 20c. Abstract of paper read before the Inst. of Min. and Met.

Cyanidation with the Brown Vat. Francis Narvaez. Min and Sc Pr—Nov. 30, 07. 1 fig. 100 w. 20c.

History of Cyanidation. Philip Argall. Min and Sc Pr—Nov. 23, 07. 3600 w. Nov. 30, 4200 w. Each, 20c. Paper read before the Colorado Scientific Society, Nov. 2, 07.

Sliming.

Slime Agitation by Compressed Air. Geo. G. Lyle. Min Rep—Nov. 21, 07. 1 fig. 1200 w. 20c.

Sliming Ore for Cyanidation. Mark R. Lamb. Min and Sc Pr—Nov. 23, 07. 1000 w. 20c.

Waste Heat in Slime Settlement. E. J. Laschinger. Min Wld—Dec. 7, 07. 700 w. 20c. Extract from discussion of paper read before the Chem. Met. and Mg. Soc. of S. Af., recently.

IRON AND STEEL.

Blast Furnace Gas.

The Zschocke System for Purifying Blast Furnace Gas. M. Wolf. Génie Civil—Nov. 16, 07. 18 figs. 4000 w. 60c.

Electric Drive in Rolling Mills.

Electrical Machinery in Steel Manufacture. W. T. Deane. Gen Elec Rev—Dec., 07. 7 figs. 3700 w. 20c.

Electric Drive in Iron and Steel Mills. W. E. Reed. El Jl—Dec., 07. 2 figs. 2400 w. 20c.

Electric Furnaces.

Qualitative Work in Steel Manufacture and Electric Furnace Operation. O. Thallner. Stahl u Eisen—Nov. 26, 07. 8000 w. Nov. 27. 6 figs. 5000 w. Each, 60c.

Stassano Electric Furnace. Min Jl—Dec. 7, 07. 3 figs. 1100 w. 40c. Describes a 200-HP. and a 1000-HP. furnace in Italy for the treatment of iron ores.

The Electrical Induction Furnace and its Employment in the Iron and Steel Industries. V. Englehart. Elek Zeit—Oct. 31, 07. 16 figs. 1500 w. Nov. 7, 07. 8 figs. 4500 w. Nov. 14. 14 figs. 1500 w. Nov. 21. 9 figs. 2500 w. (Conc.) Each, 40c.

The Electro-Thermic Production of Iron and Steel.—I. Joseph W. Richards. Jl Franklin Inst—Dec., 07. 11 figs. 4000 w. 60c. Discusses the use of electric furnaces for iron and steel production.

Ingots, Segregation in.

A Further Study of Segregation in Ingots. Henry M. Howe. Eng and Min Jl—Nov. 30, 07. 9 figs. 5200 w. 20c. Suggests that surfusion and quiet are reasons why increase of ingot-size and slow-cooling do not always favor segregation.

Iron, Specific Heat of.

The Specific Heat of Iron. P. Oferhoffer. Stahl u Eisen—Dec. 4, 07. 2 figs. 1800 w. 60c.

Ladle Cars.

Mechanical Contrivances for Use in Steel Work.—II. Fr. Frölich. Z V D I—Dec. 7, 07. 27 figs. 2000 w. 60c. Describes cars and cranes for the transportation of molten metal from the converters.

Pyrite Smelting.

The Function of the Hot Blast in Pyrite Smelting. L. Parry. Min Jl—Dec. 7, 07. 800 w. 20c.

Slag Disposal.

Slag: What to Do With It. Colby M. Avery. Min Wld—Dec. 7, 07. 1 fig. 900 w. 20c.

Steel Mills.

The Illinois Steel Company's New Rail Mill. Ir Age—Nov. 28, 07. 8 figs. 2800 w. 20c. Describes new works located on the shore of Lake Michigan, at South Chicago.

The Witkowitz Company, Moravia, Austria-Hungary. G. B. Waterhouse. Ir Age—Dec. 5, 07. 5 figs. 2100 w. 20c. Describes the large iron and steel works of this company.

LEAD.

Smelting.

Lead Smelting in Utah. R. B. Brinsmade. Mines and Min—Dec., 07. 7 figs. 5100 w. 40c. Describes the methods in use at the plants at Bingham Junction and at Murray.

TIN.

Separation of Tin from Tungsten.

The Separation of Tin-Oxide from Wolfram. Amos Treloar and Gurth Johnson. Min Jl—Nov. 23, 07. 1 fig. 2600 w. 40c. Paper read before the Institution of Mining and Metallurgy.

ZINC.

Electric Smelting.

Electric Zinc Smelting. F. T. Snyder. Min and Sc Pr—Dec. 7, 07. 1200 w. 20c. Abstracted from Transactions of the Tristate Mining Association.

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A Remedy for the Law of the Apex. Dr. James Douglas. Min Rep—Nov. 21, 07. 2600 w. 20c.

Barite.

Geology of the Virginia Barite Deposits. Thomas Watson. Bull Am Inst Min Engrs—Nov., 07. 9 figs. 7000 w. $2. Paper read at the Toronto Meeting, July, 07.

Coal Mining.

An Emergency Water Supply for a Coal Breaker. John H. Haertter. Eng and Min Jl—Dec. 14, 07. 1 fig. 1100 w. 20c.

Coal Mining and Coke Making in the Trinidad, Colorado, District. Eng Rec—Dec. 14, 07. 2 figs. 4700 w. 20c.

Disaster at Monongah Coal Mines Nos. 6 and 8. Floyd W. Parsons. Eng and Min Jl—Dec. 14, 07. 2 figs. 1200 w. 20c. Describes the probable cause of the explosion.

Mining the Coal Measures of Michigan. Lee Fraser. Eng and Min Jl—Nov. 30, 07. 8 figs. 1500 w. 20c.

The Operation of Coal Mines in Montana. Floyd W. Parsons. Eng and Min Jl—Dec. 7, 07. 6 figs. 3700 w. 20c. Describes the steam car-pusher and cylindrical revolving motor-driven tipple used in the mines at Red Lodge.

Copper.

The Braden Copper Mines in Chile. William Braden. Eng and Min Jl—Dec. 7, 07. 6 figs. 2200 w. 20c. Describes two mines in the Andes, their unique geological occurrence and the ingenious system of mining used.

The Copper Belt of California.—III. Herbert Lang. Eng and Min Jl—Nov. 30, 07. 2 figs. 5000 w. 20c.

The Gold Hill Copper Mines, and its Development. Francis C. Nicholas. Min Wld—Dec. 7, 07. 4 figs. 1300 w. 20c.

Diamond Mining.

Diamond Mining. Henry Leffmann. Jl Franklin Inst—Dec., 07. 2100 w. 60c. Abstract of a lecture delivered before the Franklin Institute, Nov. 17, 07.

Electric Winding.

The Advantages of Turbo-Alternators for Electric Winding. Coil Guard—Nov. 29, 07. 1100 w. 40c.

Explosives, Testing of.

Methods of Testing Safety Explosives. Bergassessor Beyling. Min Wld—Dec. 7, 07. 1200 w. 20c. Extract from "Glückauf."

Geological Survey Work.

Relations of Geological Survey to Mining Industry. George O. Smith. Min Wld—Nov. 23, 07. 3800 w. 20c. Paper read before Am. Mining Congress, Joplin meeting, Nov. 11-16, 07.

Gold.

Methods of Stoping at Cripple Creek, Colo. G. E. Wolcott. Eng and Min Jl—Nov. 30, 07. 5 figs. 2300 w. 20c.

Modern Gold Dredging Practice and Equipment. Horace J. Clark. Min Wld—Nov. 30, 07. 3 figs. 900 w. Dec. 14. 3 figs 1300 w. Each, 20c.

Structural Geology at Leadville. Mines and Min—Dec., 07. 3 figs. 3400 w. 40c. Describes the evidence of ascending ore solutions.

The Black Sands of the Pacific Coast.—II. David T. Day. Min Wld—Dec. 7, 07. 1300 w. 20c.

Gold and Silver.

The History of Gold and Silver. James W. Malcolmson. Eng and Min Jl—Nov. 30, 07. 3500 w. 20c. A summary of the ancient and modern uses of the precious metals, the sources of supply and the effects of supply on values. Paper presented to the American Mining Congress, Joplin, Mo., Nov., 07.

Labor-Saving Appliances in Mining.

Labor-Saving Appliances at Transvaal Mines. Edward J. Way, Engg—Nov. 22, 07. 10 figs. 4300 w. Nov. 29. 4 figs. 4400 w. Each, 40c. Paper read before the Institution of Mechanical Engineers, Nov. 15, 07.

Lead.

Chronology of Lead Mining in the United States. W. R. Ingalls. Bull Am Inst Min Engrs—Nov., 07. 5000 w. $2. Paper read at the Toronto meeting, July, 07.

Lead and Zinc Deposits of the Ozark Region. E. R. Buckley. Min Wld—Nov. 30, 07. 2500 w. 20c. Extract from report of Director of Missouri, Bureau of Geology and Mines, read before American Mining Congress, Joplin, Mo.

Mine Timber.

Steel Mine Timbers. Min Wld—Nov. 23, 07. 15 figs. 1700 w. 20c.

Substitution of Steel for Timber in Mines. R. B. Woodworth. Mines and Min—Dec., 07. 7 figs. 4400 w. 40c. Discusses timber conditions existing in the anthracite region.

Treatment Methods for Preservation of Mine Timbers. John M. Nelson, Jr. Min Rep—Nov. 21, 07. 2800 w. 20c. Describes several methods and the cost thereof, as set forth in a recent Forest Service circular.

Percussion Drill Practice.

A B C of Steam Percussion Drill Practice. John P. Hutchins. Eng and Min Jl—Dec. 14, 07. 5 figs. 2300 w. 20c. Gives Practical suggestion for unloading and setting up Keystone drills used in testing placer ground in California.

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Silver-Lead.

The St. Eugene Silver-Lead Mine, British Columbia. Ralph Stokes. Min Wld—Nov. 30, 07. 2 figs. 2200 w. 20c.

The Silver-Lead Mines of Eureka, Nevada. Walter R. Ingalls. Eng and Min Jl—Dec. 7, 07. 17 figs. 6500 w. 20c.

Sulphur.

An Improved Method of Mining Sulphur. Herman Frasch. Min Wld—Dec. 14, 07. 2 figs. 800 w. 20c.

Underground Haulage.

Underground Haulage. John Bell. Can Min Jl—Dec. 1, 07. 6 figs. 5900 w. 20c. Paper read before the British Society of Mining Students.

Zinc.

Mining Sheet Ground in the Joplin District. Doss Brittain. Eng and Min Jl—Dec. 14, 07. 3 figs. 1000 w. 20c.

Zinc Oxide: Its Properties and Uses.—II. W. G. Scott. Min Wld—Dec. 7, 07. 2000 w. 20c.

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Improving Asphalt Pavements in Kansas City. E. A. Harper. Mun Engg—Dec., 07. 1000 w. 40c. Paper read before the American Society of Municipal Improvements.

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Materials for Filling Joints of Brick Pavements. W. A. Howell. Mun Engg—Dec., 07. 1700 w. 40c. Paper read before the American Society of Municipal Improvements.

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The Density of a Pavement a Factor in its Durability. J. W. Howard. Mun Engg—Dec., 07. 900 w. 40c. Paper read before the American Society of Municipal Improvements.

Macadam.

The Construction of Macadamized Roads Suitable for Modern Traffic. Thomas Aitken. Surv—Dec. 6, 07. 4500 w. 40c. Paper read before the Glasgow Association of Students of the Inst. of Civil Engineers.

Machine Mixers for Paving Work.

Machine Mixers for Paving Work. Engg-Contr—Dec. 11, 07. 900 w. 20c.

Roads, State's Duty Regarding.

The State's Responsibility in Road Improvement. A. Marston. Eng Rec—Dec. 14, 07. 3300 w. 20c. Paper by an official of the Iowa Highway Commission.

Street Cleaning.

Municipal Work in Frankfort-on-Main. Surv—Dec. 6, 07. 2000 w. 40c. Discusses street cleaning and the removal of house refuse.

Street Cleaning in Boston. Mun Jl and Engr—Dec. 11, 07. 1200 w. 20c. Discusses littering of streets; three classes of refuse advised, with cost of each; snow removal and sprinkling.

Street Engineering.

Street Engineering. Rutger B. Green. Jl Assn Engg Socs—Nov., 07. 2600 w. 60c. Paper read before the Detroit Engineering Society, May 24, 07.

Street Sprinkling.

Data on Street Sprinkling at Washington, D. C. Engg-Contr—Dec. 4, 07. 400 w. 20c.

Tamping Roller for Compacting Sub-grades.

Compacting Earth for Sub-grades of Roads and Pavements and for Reservoir Embankments with a Tamping Roller. Engg-Contr—Dec. 4, 07. 1 fig. 900 w. 20c.

Testing Paving Materials.

Sand-Blast Apparatus for Testing Paving Materials. H. Burchartz. Génie Civil—Nov. 16, 07. 7 figs. 800 w. 60c.

Toronto, Pavements of.

The Pavements of Toronto. Gives excerpts from the City Engineer's report. Engg-Contr—Dec. 11, 07. 1300 w. 20c.

SEWERAGE AND SANITATION.

Drainage System.

A Drainage System near East St. Louis, Ill. Wilford A. Thompson. Eng News—Nov. 28, 07. 1 fig. 400 w. 20c.

Plumbing.

Plumbing, Healthy and Diseased.—I. Henry B. Davis. Met Wkr—Dec. 14, 07. 1400 w. 20c. Paper read before the Homeopathetic Medical Society of Washington, D. C., Nov. 5, 07.

Roughing-In Plumbing in Buildings. J. K. Allen. Dom Engg—Nov. 30, 07. 5 figs. 1700 w. 20c. XI.—Soil-pipe and vent fittings.

Public Comfort Station.

The Public Comfort Station in Denver, Colo. Dom Engg—Dec. 7, 07. 4000 w. 20c. Gives the plan and details of the station and the complete specification.

Purification of Sewage.

Elimination of Suspended Matters in Sewage. Surv—Dec. 6, 07. 6600 w. 40c. Gives a discussion of the subject at the Leeds meeting of the Royal Sanitary Institute.

Sanitary Engineering.

Sanitary Engineering. R. B. Owens. Can Mun Jl—Nov., 07. 7000 w. 20c. Paper read before the Union of Alberta Municipalities, Medicine Hat, Sept. 17-18.

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Baltimore's Sewerage and Sewage Disposal. Mun Jl and Engr—Dec. 4, 07. 6 figs. 4300 w. 20c.

Sewage Disposal for Institutions and Small Communities. Theodore Horton. Mun Engg—Dec., 07. 3700 w. 40c. Paper read before the Conference of New York Sanitary Officers.

The Sewage Disposal Plant at Wilmersdorf.—I. Herr Mueller. Z V D I—Dec. 14, 07. 18 figs. 6000 w 60c

Sewage Pumping Machinery.

Sewage Pumping Machinery. Mun Jl and Engr—Nov. 27, 07. 5 figs. 2600 w. 20c. Discusses the cost and efficiency of gasolene and electric plants in a number of small cities.

WATER SUPPLY.

Checking of Losses and Waste.

The Pitometer. Edward S. Cole. Jl Franklin Inst—Dec., 1907. 5 figs. 3500 w. 60c. Describes an instrument for measuring the rate of flow of water in pipes and its uses in checking underground losses and waste in water distribution systems.

Goldfield, Nev.

The Water Supply of Goldfield, Nevada. Eng Rec—Dec. 7, 1907. 4 figs. 3000 w. 20c.

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The Relation of the Interurban to the Steam Road. T. Jay Tomlinson. Elec Ry Rev—Dec. 14, 07. 1200 w. 20c. Abstract of a paper presented before the Association of Transportation and Car Acounting Officers, Chicago, Dec. 11, 07.

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Analysis of the Cost and Methods of Electric Railway Maintenance. Albert Herrick. Elec Ry Rev—Nov. 23, 07. 1 fig. 4300 w. 20c. Abstract of paper read before the Central Electric Railway Association, Indianapolis, Ind., Nov. 21, 07.

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Organization.

Organization for the Small Electric Railway. H. S. Cooper. West Elec—Dec. 7, 07. 600 w. 20c. Portion of a paper read before the American Street and Interurban Railway Association at Atlantic City on Oct. 17, 07.

Organization Problems in Steam-Railroad Electrification. Howard S. Knowlton. Eng Mag—Dec., 07. 3200 w. 20c.

Overhead Construction.

Overhead Construction on a Fifteen-Cycle Single-Phase Railway in California. St Ry Jl—Dec. 7, 07. 4 figs. 1200 w. 20c.

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THE ENGINEERING DIGEST

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ARTISTIC CONCRETE FOR RESIDENCE CONSTRUCTION

By ALBERT H. MOYER, M. Am. Soc. C. E.

CONDENSED FROM "CEMENT"

To the lay mind a well-defined style of architecture means something following in the traditional footsteps of our predecessors. The development of a new style of architecture must necessarily be an evolution, so it is not the writer's intention to discard precedent.

If you employ concrete, let it look like concrete, design for concrete, eliminate all thought of stone, brick, wood or plaster. Let the house stand up and be able to say to the casual observer, "I am solid, strong, substantial, durable, beautiful, and am of concrete." That which looks right to the practiced and trained eye is right. For country residences, particularly where there are winding roads, trees, a hillside and possibly rocks, concrete treated as concrete looks right.

In using concrete for country residences I wish the reader to eliminate from his mind all thought of concrete such as he sees about him in retaining walls, bridge abutments, and other work where concrete has been employed, but to try to picture a concrete made of selected materials, the molds or forms taken off as soon as possible while the concrete is yet green, the surface scrubbed with a scrubbing brush, or if the concrete is too stiff a wire brush, water being sprayed on with a hose, thus removing all mortar which has come to the surface, and exposing the larger pieces of aggregates; in fact, throwing them slightly in relief, giving a rough surface of accidentally distributed different colored stones.

As the walls are erected in different courses, the lower courses are from necessity stained by surplus water running down from the upper forms. This is very readily removed by washing off the walls after the house is completed with muriatic acid, which further brightens up the different particles of stone and removes any cement stain which may be on the outside surface of the stones or the mortar which bonds the stones together.

The aggregates used in the house constructed by the writer on Ridgewood Road, South Orange, N. J., are composed of 1 part Portland cement, 3 parts limestone and white marble screenings about the size of sand, 5 parts of ¾-in. trap rock, and 1 part of 1-in. white marble chips. When the boards were taken down, the surface had the appearance of the ordinary dead mouse colored concrete, but as soon as scrubbed and washed with a hose, all the particles of trap rock, white marble chips, bonded together by light colored mortar, were exposed, giving a surface which was slightly roughened and a color effect and texture which is beautiful. Photographs do not do justice to the color of this wall; it is bright and full of life. By reference to the accompanying illustration, it will be seen that the material used is concrete honestly employed; the source of strength is evident, durability, honesty, simplicity and strength being the prominent characteristics.

This treatment of concrete surfaces removes

practically all the board marks where one course of concrete bonds onto another. It eliminates the danger of temperature cracks, hair cracks, etc., showing on the surface, and gives a wall which is 100 years old at the start and which will age beautifully. Vines will add to its beauty, and if moss gathers on the north side, it will be still more beautiful. The effect is the same as that produced by a century of age.

The difference between stucco finish or mortar face concrete and exposed selected larger aggregates is that the stucco finish, even though scrubbed or treated with acid, would present to the eye too fine a grain for the large space of wall. This fine grain surface, even though of good color, becomes monotonous. Some will say that the finished block of granite shows a fine grain surface which is beautiful, forgetting that when set in a wall the surface of the wall is from convenience and necessity broken by the mortar joints. The surface of exposed selected larger aggregates gives a "Basso Relievo" effect, and their accidental therefore natural distribution throughout the concrete not only avoids monotony but brings about extreme beauty.

Ornamentation is obtained by using handmade tile of various colors, an example of its use being shown in the accompanying illustration of a portion of the front wall of the house, which includes a large front window and balcony. These pieces of clay are burned in many colors superficially or throughout the body and unglazed. The tesserae are not rectangular as in Roman or Byzantine mosaics, but are cut in multiform shapes, the contours of which help to delineate the design.

We are indebted to the courtesy of the Vulcanite Portland Cement Co., New York City, for the use of the illustration accompanying this article.

SOUND CONCRETE CONSTRUCTION

By J. T. NOBLE ANDERSON, M. Inst. C. E.

CONDENSED FROM ARTICLES IN "THE ENGINEER," LONDON

The following contribution embodies some gleanings from a practical experience of more than twenty years' continuous work as a contractors' engineer, a resident engineer, and latterly a chief, employing concrete, among various works at home and abroad.

In all concrete structures it is necessary that the foremen should thoroughly understand their business, and have the men well in hand. I have not found it practical to have more than ten or twelve unskilled men to each sub-foreman or working ganger; and I have supplemented my instructions by giving to all such men a set of printed instructions which embody the essential details in the authoritative style similar to the military manuals.

In the case of reinforced concrete the number of sources of mistake and oversights, which will be detrimental not only to the best results, but sometimes even to the safety of the structure, are such that the work certainly should never be entrusted to ordinary contractors, and it is most important that the resident engineer should be a specialist in the materials, and versed in the theory of stresses and the practical details of iron and steel work.

Hints for Resident Engineers.—The following are a few precautions which always should be taken. First, a laboratory, such as is needed for the tests required by the Standards Committee Cement Specification, must be available, and a lad or junior should be trained to test all cement continually. The easiest way to draw samples is with a grain sampler, or flour sampler, and it is a good principle to insist on every bag being sampled.

For reinforced concrete the simple test for expansion during setting is very important—and for all work the time of set should be first determined in the laboratory, and the quick-setting consignment marked on each cask or bag with some distinctive and easily noticed brand, and placed where it is not likely to be mixed with the slower setting ordinary cement. Before being mixed on the work, all cement should be tested for quickness of set, because

Fig. 1.—Child's Chair. Fig. 2.—Child's Table. Fig. 3.—Child's Bed. Fig. 4.—Child's Cupboard. Fig. 5.—Child's Bath. Fig. 6.—Child's Stool. Fig. 7.—Child's Bench. Fig. 8.—Child's Desk. Fig. 9.—Child's Wardrobe. Fig. 10.—Child's Chest of Drawers. Fig. 11.—Child's Dressing Table. Fig. 12.—Child's Washstand. Fig. 13.—Child's Cot. Fig. 14.—Child's Cradle. Fig. 15.—Child's Perambulator. Fig. 16.—Child's Pram. Fig. 17.—Child's Push Cart. Fig. 18.—Child's Go-Cart. Fig. 19.—Child's Rocking Horse. Fig. 20.—Child's Swing. Fig. 21.—Child's Seesaw. Fig. 22.—Child's Merry-Go-Round. Fig. 23.—Child's Slide. Fig. 24.—Child's Sandpit. Fig. 25.—Child's Tricycle. Fig. 26.—Child's Bicycle. Fig. 27.—Child's Motor Car. Fig. 28.—Child's Motor Cycle. Fig. 29.—Child's Aeroplane. Fig. 30.—Child's Motor Boat. Fig. 31.—Child's Sailing Boat. Fig. 32.—Child's Canoe. Fig. 33.—Child's Rowing Boat. Fig. 34.—Child's Punt. Fig. 35.—Child's Pedal Boat. Fig. 36.—Child's Paddle Boat. Fig. 37.—Child's Sledge. Fig. 38.—Child's Toboggan. Fig. 39.—Child's Skates. Fig. 40.—Child's Skis. Fig. 41.—Child's Ski Sledge. Fig. 42.—Child's Ski Toboggan. Fig. 43.—Child's Ski Stick. Fig. 44.—Child's Ski Boots. Fig. 45.—Child's Ski Bindings. Fig. 46.—Child's Ski Suit. Fig. 47.—Child's Ski Cap. Fig. 48.—Child's Ski Gloves. Fig. 49.—Child's Ski Goggles. Fig. 50.—Child's Ski Mittens. Fig. 51.—Child's Ski Socks. Fig. 52.—Child's Ski Trousers. Fig. 53.—Child's Ski Jacket. Fig. 54.—Child's Ski Hat. Fig. 55.—Child's Ski Scarf. Fig. 56.—Child's Ski Belt. Fig. 57.—Child's Ski Pouch. Fig. 58.—Child's Ski Bag. Fig. 59.—Child's Ski Rucksack. Fig. 60.—Child's Ski Tent. Fig. 61.—Child's Ski Sleeping Bag. Fig. 62.—Child's Ski Cooker. Fig. 63.—Child's Ski Lamp. Fig. 64.—Child's Ski Compass. Fig. 65.—Child's Ski Map. Fig. 66.—Child's Ski Guide. Fig. 67.—Child's Ski Instructor. Fig. 68.—Child's Ski Nurse. Fig. 69.—Child's Ski Doctor. Fig. 70.—Child's Ski Dentist. Fig. 71.—Child's Ski Optician. Fig. 72.—Child's Ski Chiropodist. Fig. 73.—Child's Ski Hairdresser. Fig. 74.—Child's Ski Barber. Fig. 75.—Child's Ski Tailor. Fig. 76.—Child's Ski Shoemaker. Fig. 77.—Child's Ski Repairer. Fig. 78.—Child's Ski Mechanic. Fig. 79.—Child's Ski Engineer. Fig. 80.—Child's Ski Pilot. Fig. 81.—Child's Ski Navigator. Fig. 82.—Child's Ski Captain. Fig. 83.—Child's Ski Admiral. Fig. 84.—Child's Ski Commander. Fig. 85.—Child's Ski Lieutenant. Fig. 86.—Child's Ski Sergeant. Fig. 87.—Child's Ski Corporal. Fig. 88.—Child's Ski Private. Fig. 89.—Child's Ski Soldier. Fig. 90.—Child's Ski Sailor. Fig. 91.—Child's Ski Airman. Fig. 92.—Child's Ski Pilot. Fig. 93.—Child's Ski Navigator. Fig. 94.—Child's Ski Captain. Fig. 95.—Child's Ski Admiral. Fig. 96.—Child's Ski Commander. Fig. 97.—Child's Ski Lieutenant. Fig. 98.—Child's Ski Sergeant. Fig. 99.—Child's Ski Corporal. Fig. 100.—Child's Ski Private.

to be too quick setting, and cakes, while being worked; in that case it is only necessary to add more water. The danger of working up again cement which has partially set, by adding fresh water and remixing, and perhaps enriching it, is greatly exaggerated in the public mind. From laboratory tests it will be found that the deterioration of such cement is but slight, and except for danger from unequal set owing to variations of richness in the concrete used in the mixture, this could be more than allowed for by a small extra admixture of fresh cement when remixing the partially set concrete. The cement should also be closely watched, any variation in the fineness or ingredients can readily be detected by rubbing between the finger and thumb.

Small samples of the mixed concrete should be taken off the boards at stated times and put to set in some convenient vessel, say a tin. These should be carefully kept on some part of the structure under similar conditions as the structure, and can be tested from time to time as an indication of how the structure is maturing. In the case of a bridge it is always well to have at least half a dozen of these.

A most important point is that gage boards should be so placed that they will facilitate the proper mixing. On most works the habit is to gage by barrows or trucks and on others large mechanical mixers of an approved design are used. Occasionally this wholesale method of work may be permitted but, generally speaking, in the case of reinforced concrete it will be found expedient to gage and mix on a planed wooden platform. The platform should be carefully leveled with a very slight gradient from the gage side to the delivery side; should be large enough to enable the material to be gaged in fairly wide boxes, and mixed three times dry, and at least once wet, before being lifted into the barrows or wagons; if to be thrown from the platform directly into the work, it must have at least two mixings when wet.

The best way to prepare the platform for mixing is to sprinkle sand over it and to brush the sand well in with the cane brushes, used on the board.

The dry mixing is done with shovels—and during the third dry mixing the water is sprinkled on the materials—the heap which then results is raked down with long-tined rakes and then turned by shovels. A variation frequently adopted is that the sand and stone, to go through a half-inch mesh, are mixed once dry and then spread out in shallow layers, and the cement plastered, dry, over them, like spreading butter on bread, then both are together thrown through a ½-in. meshed sieve. This gives a very good mixing, and is well worth the trouble; but care must be taken in windy weather to protect the mixing boards from wind, as otherwise the fine cement dust, which is the best of the cement, will be largely lost in the air, and the discomfort to the men will be extreme.

Having seen that boards and gage boxes are suitable, there are several points on which the resident engineer must be critical and hard to satisfy. Naturally the broader and shallower the boxes the more material can be gaged in them. Thus, assume that the proportions are to be 1 part cement, 2 parts sand, 4 parts broken stone, a set of boxes which might be used would be: 3 ft. × 3 ft. × 12 ins. deep for cement, 4 ft. × 3 ft. × 12 ins. deep for sand, 6 ft. × 4 ft. × 12 ins. deep for broken stone. And this would give equal results in all cases, since the extra ½ in. which the unevenness of the board and the difficulty of striking a level top may be relied on to give over the exact measurement would mean the same 4 per cent. increase to each class of ingredient.

If, however, the 6-ft. × 4-ft. gage were made twice as wide, say, 6 ft. × 8 ft., and only 6 ins. deep and the sand were made 4 ft. × 6 ft. and only 6 ins. deep, and laid on top of the stone gage, as is often done, the extra bulk which would go to the stone and sand would be at least twice the extra bulk which would go the cement, and I have known contractors gain 10% on this aggregate by this apparently harmless expedient, where, as is usually the case, the cement is not gaged. The gaging of the cement on the works is nowadays but seldom done, and to be done correctly is far too difficult and tedious a process, consequently the only place where it should be gaged is occasionally in the store or at the laboratory.

THE QUESTION OF INGREDIENTS.

As a result of long experience and many experiments the writer has adopted what he has found to be a general rule in America. If the cement mixed with three parts of sand will give the usual 300 lbs. per sq. in. tensile result at the end of four weeks, I have no hesitation in using a reinforced concrete consisting of 1 part cement, 2 sand and 1½ broken stone. This is permissible where the work-

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ing stresses will reach 500 lbs. compression and 50 lbs. tension per sq. in. These stresses may be applied when the structure is one month old.

When the concrete is required to be water-tight the question of properly proportioning the ingredients is vital. The mixture must be given so thorough a working together that voids will be all filled. Unless some material, such as inferior bricks, pumice, or tufa be used, the material of which the concrete is compounded is of itself practically impervious. Clean, sharp sand with finely ground cement sets into a material of a character very impervious to ordinary water, so that a mortar made of two parts sand to one part cement, where the cement has been sufficiently fluid, and well enough worked to cover all the surfaces of the sand particles, and to flow into and completely fill all the spaces, will give as good results as the best non-absorbent stoneware, or the best vitrified bricks. When such a mortar is used with granites, or the best quality of trap rocks, if the resulting material should prove to be porous, the methods of mixing adopted are at fault.

Having decided on what materials will be available, the method of finding the least proportion of cement and sand which will give a water-tight concrete is as follows: Obtain a truly cylindrical glass vessel. For accurate results this should be of several gallons capacity and with clear graduations, high rather than broad. This should be placed in a basin or tray of almost as large capacity as itself. Fill the vessel with water to the brim, see that the basin in which it stands is dry, and then gently place in the water the pieces of material the interstices between which are to be measured. The displacement of the material will be the quantity of water which flows over from the vessel into the tray and the difference between this quantity and that which was originally in the graduated vessel is the measure of the voids or interstices. This quantity can be measured in the graduated vessel after the latter has been emptied. If the method of taking the material out and reading the measure of the water left in for the measure of the voids be adopted there will be an error due to the wet material having taken a certain amount of water away with it. Any mistake of this kind will be in the wrong direction; hence the method first described is to be preferred. Another word of practical warning. It has been recommended that the material be "gently" placed in the measuring vessel, while in making concrete, the material would be rammed, tamped, and shaken so as to go into the least possible space. The reason for the different treatment in this laboratory experiment is that material when in water can be consolidated much better than could be the case in a drier state. Any attempt to consolidate the material in the measuring vessel would result in a better consolidation than would be obtained in practical every-day work, and the estimation of the voids would be less than they are in the work. In this matter, while the greatest care must be taken that the measurements and methods be scrupulously accurate, the fact must not be lost sight of that what is wanted is an estimate to assist in guessing what will take place in the work. The rough methods of practical work demand every consideration, and where judgment comes into play, things must be so arranged that the unavoidable error will occur on the safe side.

In the case of sand, the methods of gaging the displaced water will be found to give results varying from about 37% to 40% of interstices. With clean broken stones the voids will probably vary, according to the material used, from 45% to 60%. Taking them as 50% and the sand at 40%, the aggregates, assuming perfect mixing, will work out at 1 cement, 2½ sand, and 5 broken stones. These conditions admit of no waste nor do they assume any irregularities in the mixing. It is, therefore, as well to state positively at the outset that with no ordinary material is it possible to get a concrete made of 1, 2½ and 5 which will not leak, and in the case of a narrow wall, leak badly.

It may seem surprising, but in the laboratory I have with the most thorough and accurate tests verified that frequently concrete is not only made more porous by washing the sand, but is actually sometimes made weaker in tensile and compressive strength, and as a rule I do not recommend that sand should be washed for reinforced concrete work. I have on occasion abandoned sand which could be procured at 2s. 6d. per cubic yard, but which required washing, and have purchased in place of it sand at 13s. 6d. per cubic yard, where my material was reinforced concrete for a bridge span.

With 1, 2 and 4 for the proportions it is just possible to obtain a fairly water-tight concrete with the best possible working.

With certain kinds of stone, such as the millstone grits, it is practicable to use all one

material because the crushing produces sufficient sand. In the case of trap rock, however, the "fine" or "dust" material contains a certain quantity of soluble salts, with an excessive quantity of alumina, which causes a swelling of the material, and may lead to disintegration of the concrete. Consequently, this material can only be used when well screened, and the sharp small chips will be found to be the safest form to use.

Care must be taken to see that the stone crushers do not leave the stones with minute fractures. Of course, there are stones which will be badly damaged in this way under any stone crusher, and with such stones only hand knapping is allowable.

There is another question raised by the practice of using broken stones of larger size. I refer to the use of large stones, commonly known as "displacers," or "plums." The use of these is generally considered to cheapen the work and greatly to improve its quality and strength if properly bedded. Obviously, the whole difficulty is to secure proper bedding. If the "plums" are placed too closely together, or are disturbed during ramming, a certain amount of cavitation is inevitable. On this account I always direct that the least distance between displacers must be 4 ins., and, similarly, that there must be 4 ins. between displacers and the shuttering. If larger ramming tools are used, this space may have to be greater, so that the ramming can be effectively done at every point. Where there are cranes provided to lift the displacers and bed heavy stones weighing several tons, care must be taken that they are not placed so closely together as to prevent workmen from freely working round every side.

The small boulder class of displacer is objectionable from every point of view; it is much harder to obtain clean and free from inferior rock, and unless practically cubical in shape it is bothersome to bed and does not give the volume of displacing material if properly spaced that the larger stones will give.

The writer's practice has been to pay a "flat price" for the whole finished concrete, and only to allow such large displacers as have been approved, numbered, and checked at the quarries to go into the work. In all my works I supply the contractor with the cement, so that the people for whom the work is being done have the whole benefit from any saving in the quantity of cement used.

The question of possible unequal expansion with heat in this material, from the differences between the expansion coefficient of concrete and stones, is not so serious as at first it might appear, because except with the richer mortars 1½ or 2 to 1, where the coefficient of expansion is sometimes as high as .000011 per degree Centigrade, the expansion of concrete will not be found to vary materially from the expansion of the rock material principally used in its construction; and where the richer mortars are used, the tensile strength of the mortar is such that the slight unequal expansion cannot cause any strain that is not well within the permissible internal strain of the material. This remark applies to all temperatures short of those which could be obtained by a fierce combustion under a draft.

A great deal has been written on the inferiority of concretes made from gravels. The generally accepted idea is that the rounded surfaces do not give so good a key for the cementing mortar to catch on to, and that the adhesion is inferior.

Personally, I have not had enough laboratory tests to rely on in the matter, but I am strongly in favor of gravel concrete, and have met many cases where it was substantially better and stronger than an apparently equally rich stone and sand concrete. Incidentally, it may be mentioned that the greatest users of reinforced concrete, so far as I have seen their works, have all shown a preference for gravel, and generally without or with a very slight admixture of other material except the cement.

METHODS OF CONSTRUCTION—"FALSEWORK" AND FINISH.

In modern concrete work, reinforced as arches or beams, used in place of cast iron, steel or timber, for joists, for fireproofing, or for decking, the designer finds his responsibility great, and he must arrange for and specify in detail every particular of construction, making elaborate plans of the "falsework," showing every joint in the "framing," and giving the dimensions of "shuttering." The commonest mistake is to use too light timbering.

Generally speaking, to secure sightly finish the shuttering should not be less than 2 ins. thick, and of well-seasoned pine. The best timber is yellow pine. If the surfaces are to be exposed, the boards should be planed. For ordinary rough work, the surfacing which the buzz machine puts on the timber will suffice. Care must always be taken that the joints are planed to give a perfectly tight fit, as otherwise the concrete

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should always be made very fluid, will run away through the joints, leaving slight cavities. A common American method of securing tightness is by using oiled paper, which may be either nailed or glued to the surface of the shuttering. When a finished surface is wanted, it is well to remove all laggings and shuttering as early as it can be taken away with safety to the structure, and, before the surface has set hard, get it rubbed smooth with a hard wood surfacing tool, and then rub on a good thick wash of pure cement. To secure a uniform color some suitable pigment, such as chrome, may be added to the concrete.

A more important point is the framing to carry the shutters. The members of this should be designed close enough together, and of stout enough scantlings to be quite rigid, and admit of the hard ramming of the concrete, without that damaging vibration and jumping which often, where work is going on continuously for several hours, causes the working on the fresh stuff to jar the earlier work which is just beginning to set. Then they must be jointed and tied together in such a way that as soon as the concrete has begun to set they can be eased; and then when they come to be removed that they may fall right away from the finished work, which, unless very firmly set, will always be liable to chipping or even serious damage from any jamming or forcing due to drawing asunder the timbers, which have swollen with the moisture of the concrete in working. A little skill in the use of wedges will allow of almost all that is wanted being obtained with them. Screws and tenon joints will do the rest. Where the pressures are considerable, hard wood and soft wood wedges, used in pairs, driven in opposition, are best, and give a level uniform bearing which cannot be got in any other way.

In the case of reinforced concrete, a detail of great importance is the provision of means for holding the steel reinforcements in their places while concrete material is being rammed round the reinforcing framework.

Expansion.—A matter of great importance is to make provision for expansion during and after setting. In the case of floors in a store, it is possible that the nature of the service may preclude much change of temperature, and the only expansion to be provided for will be whatever occurs in the chemical and physical changes of the setting of the concrete. With a good cement protected from rapid desiccation by being covered and kept continuously wet until well set, the only provision is such as slacking the wedges, and freeing the concrete from external stresses coming upon it; quite a large area will stand without any sign of distortion, because the strength of the material against compression is so great that any internal compressive stress it may receive due to its own expansion will have no detrimental effect. With a subsequent cooling, however, unless the material has been very well strengthened by reinforcement against tensile stresses, and is of sufficiently rich aggregate to give good adhesion, cracks are bound to develop. The extent, however, to which well designed and constructed reinforced concrete will take up such stresses is simply amazing to anyone with preconceived prejudices from experience with ordinary concrete. It can be shown theoretically that there is no necessity to make provision against failure from expansion and subsequent shrinkage. Where, however, the necessity for such provision for expansion, e. g., expansion joints, comes in, is when unreinforced or partially reinforced parts are carried on reinforced works which have been so placed and designed as to admit of some breathing or distortion.

I have merely attempted to give some rough practical points in connection with this most important question. There are a great number of abstruse, and often puzzling, phenomena, arising from questions of elasticity, which would demand a special treatise. One practical point of frequent occurrence should, however, be noted—this is what is known as the "map cracks," which almost always occur sooner or later on well finished and smooth cement surfaces. These can to a great extent be obviated when the surface is carefully covered and kept moist until it has very thoroughly set.

If the cement is of the very best, and the surface is not too soon exposed to the sun or drafts, there is every probability that no "map cracks" will occur with such works. With internal surfaces, a common expedient is to rub down the surface with a rich mixture of cement and water. Commonly, this mixture is weakened by an adulteration of about 70% of fine sand being mixed or ground into the cement. Whether this has much real benefit in preventing these fine hair cracks from occurring I am not prepared to say. However, from not having so dark a color or so smooth a surface it is much more difficult to notice them.

The question of the adhesion of the mortar to the steel is most vital; without it the grid

does more harm than good, making a plane of division in the middle of the material. It cannot be too strongly urged that the best way to insure adhesion is to make the mortar with plenty of water, and use plenty of cement in its composition.

A great deal has been said, and there are many different views on the question of whether rust injuriously affects adhesion. I had a number of laboratory experiments made to determine this question, and in almost every case the clean wire was found on tests up to three months after setting to give the better adhesion, and in some cases the superiority was very marked. Consequently I adopted the rule that all mild steel or wrought iron rods should be cleaned before being cut up to their sizes for the work, then painted with cement wash, and stored handily for assembling on the work. In factories for the manufacture of reinforced concrete articles, the rule is to use only the best tinman's wire.

Practical Points on Reinforcing Steel.—Generally speaking, the points which most demand attention in designs are not so much questions of the factor of safety nor the exact position in which the reinforcement is placed, as the practical considerations of whether the reinforcement can be introduced and kept in the desired place while the concrete is being rammed or tamped, for any subsequent movement would have a very prejudicial effect. Movement while being embedded in the concrete will probably disturb things so that the reinforcement will not be situated exactly where it is designed to be situated, while movement after the concrete has begun to set will mean that the adhesion between the concrete and the steel will be destroyed.

Among these practical points is the question of the richness of the mixture. A water-tight concrete should always be aimed at. I would feel much inclined to rule out any reinforcement which made a general use of such rolled sections of iron or steel as angles, tees, zees, or crosses, except where these steel sections act independently of the concrete. I believe that the chief cause why I have always found reinforcements of this kind to give unsatisfactory results is similar to that which makes external angles in concrete a weak point, or that makes sharp angles in cast iron, or sudden changes of section, sources of danger, namely, that there is always a state of internal stress, and that the strains become unequally and irregularly distributed when there is any sharp angular shape concerned with it. To some extent, also, I have found an otherwise unaccountable weakness where flat iron is introduced. It is not my province here to discriminate between rival systems. My own practice is to stick to round rod reinforcement and to avoid too large sections, because in such large bars as 2 ins. in diameter and upwards, either the lengths are inconveniently short, or else there is a danger that welded lengths may inadvertently be used. I would prefer three bars, each of 1¼ ins. in diameter, placed so as to break joint on every occasion to a single 2-in. diameter rod. When allowance is made for the thimble or whatever joint is made to take up tension, it will be found that one system is not more bulky than the other.

"Fatigue."—So far there are no classic experiments on the fatigue of concretes like Wöhler and Bauschinger's on steel and iron. And the records of such tests as have been published, e. g., Van Ornum's in the "Proceedings," American Society of Civil Engineers,, vols. LI and LVIII, suffice to show how great are the difficulties in this field of research. However, from its behavior under highway road traffic, electric tramway traffic, and such railways as are to be found in the Alps, one feels no anxiety on the score of its durability. Certainly none of the failures which have been recorded of this material can by any stretch of the imagination be connected with either old age or "fatigue." So far as the steel is concerned, from all experience of this material we know that with the light tensile stresses, to which it will be subjected in any well-designed reinforced concrete, it ought to be practically everlasting. Whatever effect the imbedding in cement mortar could have on it must be beneficial, as this has long been proved by an experience, now almost measured by centuries, to be one of the best preservatives against rust.

On the other hand, so far as the concrete is concerned, that and kindred cements have been proved by an unimpeachable experience to be among the most durable of all materials.

The only novelty which might demand caution is the mere text-book novelty of using masonry in tension. But anyone who has studied old works intelligently, and has been sufficiently interested to calculate the actual stresses to which they have been and continue to be subjected will know that this is no novelty, and that the slight strains of well-designed work will introduce no element of danger.

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FLOW OF WATER IN OPEN CONDUITS

By A. P. MERRILL

CONDENSED FROM "THE ENGINEERING RECORD"

In their evolution, the principles of what we term "hydraulics," like other branches of applied science, have been variously modified and changed in order that they may be made to conform with observed facts. It was about the middle of the eighteenth century when Brahms and Chezy proposed the well-known formula, $V = C \sqrt{RS}$, and it has been very extensively used since that time. The coefficient, C, was at first supposed to be a constant, but as time advanced and experiments began to be made, it became evident that the expression must be modified.

It is a little curious that many of the investigators have accepted, without question, the relation between the velocity, the hydraulic radius and the slope as proposed by Chezy, and have turned their attention to the coefficient, C, aiming to find some law by which it might be varied. The most noted of these are Ganguillet and Kutter, and it is the law proposed by them for the variation of this coefficient that is most extensively used today. This expression, while somewhat cumbersome, has been made quite easy of application by the various diagrams now in use. But is the general law with which Kutter's coefficient is used, correct? While the expression proposed by him is recognized by all as being very ingenious, and while the mathematical skill required in its development is no doubt beyond that possessed by many, yet if the Chezy formula does not involve the true law, then Kutter's proposed equation for the coefficient is merely a mechanical device designed to enable us to approximate the truth when applying a law which does not express it.

It was while the writer was working for his Master's degree at the University of Michigan that Prof. Gardiner S. Williams proposed the subject "Flow of Water in Open Conduits" as a suitable one for a thesis investigation, and the suggestion was gladly accepted. In studying this subject, the writer aimed to cast aside all preconceived notions as to what the various relations should be, and when the results obtained suggested a new working hypothesis, he did not hesitate to try it. This meant that much work was done on assumptions that were erroneous, and were necessarily discarded.

The results of the admirable experiments commenced by Darcy and completed by Bazin formed the basis of the greater part of the investigations made. The measurements recorded in forty-one of their tables or "series" were used. They were taken from "Hydraulics," by Hamilton Smith, Jr. The general conditions under which these results were obtained, and the methods of experimentation, are too well known to need special comment here. Measurements were also used which were made on the Sudbury Conduit by Fteley and Stearns, on the Linth Canal at Grynau by Legler, on the Seine at Paris by M. Poiree, on the flume of the Puget Sound Power Co., in Pierce Co., Wash., by Jos. H. Cunningham, and on the flume of the Ulysses Heat, Light & Power Co., at Taughannock Falls, N. Y., by Messrs. Bell, Goodrich, Haefner and Thompson. Besides these, there were results used that were taken from the Roorkee Experiments by Capt. Allan Cunningham, and also some made by Rittinger.

The formula finally developed is

$$V = C S^a R^b,$$

in which

V = velocity of flow in feet per second.

S = slope, or the sine of the angle of inclination of the conduit.

R = hydraulic radius, or the cross-sectional area of the stream divided by the length of the wetted perimeter.

The following is a summary of the numerical results:

Ordinary Conduits: $a = 0.43$; $b = 0.869/V^{0.25}$

	C
For unplaned plank	= 78
For lath in flume .12′ c. to c.	= 64
For lath in flume .25′ c. to c.	= 44
For pure cement	= 94
For small gravel	= 56
For large gravel	= 45
For brick (not very smooth)	= 75
For smooth masonry	= 77
For ordinary channels in earth	= 22—32

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Semicircular Conduits: a = 0.46; b = $0.929/V^{0.25}$.

	C
For partly planed plank	= 97
For pure cement	= 114
For cement with one-third sand	= 104
For small gravel	= 74

Rivers and Large Canals: a = 0.76; b = $1.552/V^{0.25}$; C = 174 to 248.

It is seen that C in the above summary varies through a wide range for rivers and large canals. The investigation on these large streams was not sufficiently extensive to warrant giving a more definite coefficient.

After the final exponential equation was determined, and the values for the coefficient obtained, the writer computed, by the formula submitted, the values for the velocities, using each of the readings given in 43 of the tables used. With one exception, the average computed velocity for each table differed from the average measured velocity by less than 6%, while in the majority of cases, the difference was under 2%.

THE DESIGN OF MACHINERY BEARINGS*

By J. T. NICOLSON

The chief aim of this paper is to attempt an elucidation of the phenomena of the resistance offered to the relative motion of lubricated surfaces, and in particular of journals and bearings which run at constant speeds and under loads constant in magnitude and direction—as used in engineering practice.

The experimental results of Stribeck, Dettmar, Helmann, and Lasche, as well as those of Beauchamp Tower, Thurston, and others, have been utilized for the purpose of framing rules for the sizing of journals of the different types used in practice. It is believed that the formulas thus obtained give a better approximation to practical requirements of the most divergent kinds than has hitherto been obtained. In particular, the view commonly held that the length of a bearing should increase in proportion to the speed is shown to be erroneous.

Frictional Resistance Due to Viscosity.—It is frequently stated that "there is no friction without abrasion," or, in other words, that unless two metals rub against each other, there can be no resistance due to relative motion. This, however, is not the case. When a film of lubricant is interposed between two metallic surfaces there is a resistance to relative motion of these surfaces due to the shearing or transverse distortion of the oil film.

In the case of the shearing of a solid, we know that Hooke's law, "ut tensio sic vis," applies; so that if q be the shear stress, and s/y the shear strain, we write $q = G\, s/y$, where G is the modulus of transverse elasticity. But if two surfaces are separated from one another by a liquid of thickness y, and one of them moves with speed v relatively to the other, the resistance no longer depends upon the mere magnitude of the angle, of which s/y is the tangent, but upon the rate of its increase with time. If a is the area of either liquid surface, the force required to maintain the steady speed v is $F = qa = kav/y$, where k is called the coefficient of viscosity of the liquid. [This coefficient is clearly that force which will move a unit area of surface with unit speed relatively to another surface from which it is separated by unit thickness of the liquid in question.]

A film of oil of uniform thickness, y, all round a journal of diameter d and length l, and adhering to it and to the bearing surrounding it, will thus oppose a resistance to the rotation of the former with surface speed v of the amount

$$F = k\pi dlv/y \quad \ldots\ldots\ldots\ldots (1)$$

In such a case the friction would not depend on the load, which does not appear at all in the expression; and it will be readily admitted that the force required to distort the oil film cannot depend on the fluid pressure to which it is, at the moment, subjected. The friction is governed only by the area of viscous fluid to be sheared, and the viscosity of the oil, i. e., the kind of oil and its temperature (with which the viscosity greatly alters), and it also gets greater the smaller (y) the thickness of the film, so that if the journal is a close fit within its bush the resistance to motion will be greater than if the fit is an easy one.

*From a paper on "Friction and Lubrication," read before the Manchester Association of Engineers, November 28, 1907.

There are, unfortunately, very few cases in engineering practice, where a journal rotates with a uniform thickness of oil around it. It is only when the speed is very great indeed that this can happen—as with steam turbines and mill spindles. At moderate and low speeds we know that the shaft moves to one side by an amount which depends on the speed and the load, the eccentricity for any given load becoming less the greater the speed. We have just seen that the frictional resistance depends on the thickness of the oil film, but it is known from the researches of Osborne Reynolds, and Sommerfeld that the diminution of frictional resistance, due to the thickening of the film on one side of the shaft, is more than made up for by its increase due to the thinning on the other. On the whole, therefore, the friction gets greater when the journal becomes more eccentric.

Starting, therefore, with a bearing running slowly, in which the lubricant has just formed a complete film all round the shaft, it will have its maximum amount of eccentricity, and the frictional resistance will on this account be large.

As the speed is increased, the eccentricity diminishes. The friction should, according to the simple law of oil shearing given above, increase with the speed, but it should diminish, on the other hand, with the eccentricity. We find, in fact, that at first it diminishes more than it increases, and in this way (the coefficient of friction) attains a minimum value which depends on the circumstances. With further increase of speed the diminution of friction due to the lessening eccentricity becomes insignificant, and for a certain interval the simple law of friction is followed, whereby the friction increases proportionally to the velocity of rubbing.

For speeds greater than about from 20 ft. to 80 ft. per minute (depending on the kind of bearing) the simple law of fluid friction is interfered with for another reason.

On account of the high speed, the temperature in the oil film itself rises above that of the bearing (even when the latter is artificially maintained constant) and its viscosity becomes reduced. The frictional resistance then increases less rapidly than in exact proportion to the speed.

The faster the journal runs, the more the temperature of the oil film rises above that of the bearing, and the thinner or less viscous becomes the oil. For speeds from 50 to 90 up to about 450 ft. per minute, the coefficient of friction is proportional to the square root of the speed of rubbing. For speeds between 450 ft. and 800 ft. per minute the friction increases more slowly still, and, according to Thurston, μ varies as $v^{0.2}$. For speeds of the order of 3,600 ft. per minute and upwards, the influence of speed disappears altogether, and the conclusion arrived at by Lasche is that, for the bearings of high-speed generators driven by steam turbines, whose rubbing speeds are nearly a mile a minute, the coefficient of friction is the same whatever be the speed.

The Coefficient of Friction of Lubrication.—The term "coefficient of friction" denotes the ratio of the total resistance in the bearing due to the shearing of the lubricant, to the load of the journal; and although it has no physical meaning, it supplies a convenient and conventional method of discussing the details.

If F denote the resistance, and P the load, we have

$$\mu = \frac{F}{P} = \frac{k\pi dlv}{Py} \quad \ldots\ldots\ldots\ldots (2)$$

and if P/dl be, as usual, denoted by p, and called the bearing pressure, or load per unit of projected bearing area, we see that

$$\mu = \frac{k\pi}{y}\frac{v}{p} = c\frac{v}{p} \quad \ldots\ldots\ldots\ldots (3)$$

or the coefficient of friction would vary as the speed and inversely as the bearing pressure if the oil film were of uniform thickness all round, and the temperature of the lubricant were constant.

Heimann's experiments on a solid bush bearing of gun metal show that μ increases less rapidly than the velocity of rubbing when the speed is greater than about 20 ft. to 80 ft. per minute. This is due to the fact that the difference between the actual temperature of the oil film and that of the bearing gets greater as the speed increases, so that although the bearing temperature may remain the same throughout a series of experiments, that of the film of lubricant itself, upon which the value of k—the coefficient of viscosity—depends, does not. Thus μ falls away from the simple linear law the more the greater rubbing speed becomes.

These—as also Beauchamp Tower's experiments—show that the "coefficient of friction" in a lubricated bearing follows the law $\mu = (cv/v)/p$ (instead of $\mu = cv/p$, as given above).

Upon further examination of the experimental results we observe that for speeds below about 20 ft. per minute the coefficient of

friction diminishes for a little in exact proportion to the speed, but that the effect of the relatively great eccentricity of the journal in the bush soon begins to have an important influence in increasing the friction; so that after a while the curves of μ take reverse turns, and the coefficient attains a minimum value as described above.

The curves all rise very rapidly when the speed is very slow and the oil has all been squeezed out of the bearing; and that they tend to converge upon the constant value 0.15, the coefficient of friction for greasy metals sliding upon each other, long ago determined by Morin. It is only then that μ remains constant, and that we encounter a frictional resistance and loss of work proportional to the load on the bearing and of the amount already calculated.

Formula for Coefficient of Friction.—Reverting to the theoretical law of fluid friction mentioned above, viz.:

$$\mu = \frac{c\,k}{y}\,\frac{v^n}{p}$$

we find that experiments show that n has values diminishing from ½ to 0 as the speeds increase from 100 ft. to 3,600 ft. per minute. Clearly, the variation should be made in the value of k, the viscosity coefficient, and not in that of v; for the law of shearing resistance is equally kv/y at high as at low temperatures.

If we could calculate the excess of mean temperature of the oil film over that of the metal walls between which it is flowing, then knowing how k depends upon that (mean) temperature we could predict the proper form of the expression for any given case.

The author has found a simple expression which gives the values of k with fair correctness between the temperatures 70° and 160° F.

The formula is

$$k = \frac{B}{(t - 60°)}, \text{ or } k = \frac{B}{\theta},$$

where B has the value $\frac{1}{500}$.

Thus we write:

$$k = \frac{1}{500\theta} \quad \ldots\ldots\ldots\ldots (4)$$

A roughly accurate expression for the coefficient of friction for machinery oil as deduced from these experiments will therefore be (for speeds over 20 ft. per minute).

$$\mu = \frac{c\sqrt{v}}{\theta p} \quad \ldots\ldots\ldots\ldots (5)$$

$$\mu = \frac{900\sqrt{v}}{500\theta p} = \frac{1.8\sqrt{v}}{\theta p}. \quad (6)$$

Here v = surface speed in feet per minute,
p = bearing pressure in pounds per square inch,
and θ = excess of oil temperature above 60° F.

This may be written in the form:

$$M = \mu p = \frac{1.8\sqrt{v}}{\theta} \quad \ldots\ldots\ldots\ldots (7)$$

where M may be called the specific friction. It is the frictional resistance per square inch of projected bearing surface.

The quantity $\mu p = M$ is obviously proportional to the frictional resistance or force per square inch of journal area, for the total work spent on friction per minute is $F\,v = \mu\,Pv = \mu\,p\,d\,l\,v = M\,v\,d\,l$.

If we divide by dl we obtain (Mv) the friction work per minute per square inch of projected bearing area, and M is the force of friction per square inch of that area.

A journal starting from cold at a given speed v will warm up until the heat emitted is equal to that generated by friction.

Its temperature will then be $\theta\,f = 0.66\,v^{\frac{1}{2}}$

$$= \frac{(d\,N)^{\frac{1}{2}}}{4}$$

The excess of this temperature over that of the surroundings (say 60°) is proportional, according to Newton's law of cooling, to the heat emitted (per square inch of bearing area) per minute (e θ).

If now the bearing length were suddenly doubled, the bearing pressure (p) would be halved; but the value of M would (to a first approximation) remain unaltered, for the frictional resistance is quite independent of the pressure in the oil film, being governed only by the rubbing speed (i. e., the diameter and the revolutions per minute), and the temperature of the bearing.

The speed has not altered with the change of length, and the temperature also will not change; for, although the total heat generated in the bearing by friction has doubled, so also has the surface for emitting heat. An alteration in the length will not, therefore, produce any change in the heat generated or dissipated per square inch or in the temperature of the journal.

If running hot before, it will run hot still; we gain nothing from this point of view by lengthening the journal, and, in fact, the total loss by friction will be increased in the exact proportion in which the bearing has been lengthened.

What we gain by increased length is a diminished liability to rupture of the oil film (on the "off" side of the point of nearest approach), and to the consequent running of the journal and bearing in metallic contact.

Application of the above Formula in the Design of Bearings.—In endeavoring to apply the theoretical explanations and experimentally derived formulas discussed above to the design of a bearing, what we want to know is: What is the proper proportion of length to diameter under any given conditions as to load, speed, and mode of lubrication; having regard also to the fact that the requirements demanded from the point of view of strength and stiffness must also be met.

We have to consider how much heat is generated by the viscous resistance opposed by the oil to the rotation of the shaft, in what manner this heat is dissipated, to what temperature the bearing will rise in actual running, and what law connects the temperature at which the journal may safely run with the pressure and the speed.

The heat generated is obviously equal to $\frac{\mu P \pi d N}{12 J}$ thermal units per minute, if d is the journal diameter in inches, P the load in pounds, μ the coefficient of friction, and N the number of revolutions per minute.

If the heat dissipated by radiation from the surfaces of the housing and shaft be, as usually assumed, proportional to d l, the projected bearing area, and to θ the temperature difference between bearing and external air; then, when the temperature of the bearing becomes steady, we shall have (e being the emissivity coefficient)

$$\frac{\mu P \pi d N}{12 J} = e d l \theta \quad \ldots\ldots\ldots (8)$$

In the standard text-books it is usually assumed that whatever may be the diameter or length of the proposed journal the value of μ will remain constant. In that case

$$l = \frac{\mu P \pi N}{12 J e \theta} = \frac{\mu \pi}{12 J e \theta} P N = \frac{P N}{\beta} \quad \ldots\ldots (9)$$

which means that the length of the bearing must increase with the load and the revolutions.

As a matter of experimental fact, however, μ is by no means constant. It depends on speed, pressure, and temperature, and, as we have already seen, we may take it to follow the law

$$\mu = \frac{1.8 \sqrt{v}}{\theta p} \quad \ldots\ldots\ldots\ldots (10)$$

The more correct method will be to use the value for the coefficient of friction which has been determined by experiments upon bearings as above described.

If, then, we insert this value in (8), we obtain

since $$v = \frac{\pi d N}{12}$$

$$\frac{c P (\pi d N)^{\frac{3}{4}} l}{12^{\frac{3}{4}} p \theta J} = e d l \theta$$

With $c = 1.8$, $\frac{P}{p} = l d$, and $J = 778$, we get

$$\theta^{\frac{7}{4}} = \frac{(d N)^{\frac{3}{4}} l}{3{,}400 e} \quad \ldots\ldots\ldots\ldots (11)$$

To determine the value of e, the emissivity coefficient, we may apply this formula to Stribeck's results from his Sellers bearing. This bearing of diameter 2.76 ins. attained—according to that figure—after running for three hours at 760 r.p.m., a final temperature of about 140° F. ($\theta = 80°$).

Therefore $$e = \frac{(2.75 \times 760)^{\frac{3}{4}} l}{3{,}400 \times 80^{\frac{7}{4}}} = .1_6 \text{ B. T. U.} \quad (12)$$

dissipated per square inch of projected bearing area per minute per degree F. difference of temperature, between the bearing and the outer air.

Thus the formula for θ, the final rise of temperature of a bearing above its surroundings, becomes

$$\theta = \frac{(d N)^{\frac{3}{4}} l}{\sqrt{3{,}400 \times .1_6}}$$

or in round numbers

$$\theta_t = \frac{(d N)^{\frac{3}{4}} l}{4} \quad \ldots\ldots\ldots\ldots (13)$$

Expressed in words, this means that the steady or finally-attained temperature of a bearing of given diameter is higher the greater the ¾ power of the revolutions, and is greater for a given speed the larger the ¾ power of the diameter. It is, however, quite independent of the length of the journal.

We cannot, therefore, hope to lower the terminal temperature by lengthening the bearing. The heat generated increases as fast as the area for dissipating it does; for although by lengthening the journal the bearing pressure is diminished, yet since μ varies inversely as p, the frictional resistance and the heat generated are pari passu increased.

We know, however, from experience, that journals must be made long for high speeds, and the above conclusion seems at first sight to conflict not only with the text books, but also with practice, and so to be paradoxical.

The explanation is as follows: While it is true that the final temperature to which a bearing will rise after a long run under a given load and with a given lubricant, depends only on the diameter of the spindle and on the speed of revolution, i. e., only on the rubbing velocity, and not at all upon the length of the journal, we have to remember that if that finally-attained temperature be too high the lubricant will be squeezed out unless the bearing pressure is low.

The conditions attending the minimum values of the coefficient of friction are those under which the oil begins to escape from the bearing, and that for any lower speed the bearing will run dry, we may find the connection between rubbing speed and temperature on the one hand, and rubbing speed and pressure on the other, which specifies the condition of safe running with a complete oil film.

Sommerfeld has deduced mathematically an expression for this very speed for the minimum coefficient of friction, in terms of the bearing pressure, p; the radius of the journal, r; the difference between the radii of bearing and journal, δ; and the coefficient of viscosity, k.

It is of the form

$$v_o = K \frac{\delta^2}{r^2} \frac{p}{k} \quad \ldots\ldots\ldots\ldots (14)$$

We also found above that the coefficient of viscosity for machinery oil is, for temperatures between 68° F. and 160° F., well represented by the expression $k = \frac{c}{(t° - 60°)}$ or $k = \frac{c}{\theta°}$ (units = pounds, feet, and degrees F.).

Substituting for this k in (14) we obtain

$$v_o = C\, p\, \theta \quad \ldots\ldots\ldots\ldots (15)$$

where C is a constant, varying as the square of the ratio of the original slackness of fit to the size of the journal.

We shall use for our purposes in designing bearings the expression $v_o = C\ p\ \theta$, with C = 1/∞ for the value of the constant; and when written in the form

$$\theta_c = \frac{40\ v_o}{p} \quad \ldots\ldots\ldots\ldots (16)$$

we see that it gives the critical value (θ_c) of the rise of temperature above which, under the given conditions as to surface speed (v_o feet per minute), and bearing pressure (p lbs. per square inch), the oil will be in danger of leaving the bearing and allowing it to run with metallic contact of the rubbing surfaces.

What we are now proposing, then, is to fix the proportions of journals by reference to the minimum points of the experimental friction curves already discussed, assuming them to indicate the critical conditions as regards speed, pressure, and temperature of the bearing, below which it is unsafe to run.

We first calculate the terminal rise of temperature of the bearing by the expression $\theta_t = \frac{(d\ N)^{\frac{1}{2}}}{4}$. We then equate this to the value $\theta_c = \frac{40\ v}{p}$ of the above critical temperature; and so obtain a relation between the length, the load, the diameter, and the speed of revolution.

We thus have

$$\frac{(d\ N)^{\frac{1}{2}}}{4} = \frac{40\ v}{p}$$

Substituting $\frac{\pi\, d\, N}{12}$ for v, and $\frac{P}{l\, d}$ for p, we may write this

$$\frac{(d\ N)^{\frac{1}{2}}}{4} = \frac{40 \pi\, d^2\, N\, l}{12\, P},$$

from which we obtain

$$l = \frac{P}{40\, d\, (dN)^{\frac{1}{2}}} \quad \ldots\ldots\ldots\ldots (17)$$

This is the formula proposed for use in the design of journals for speeds of rubbing up to about 450 ft. per minute.

It has been found to agree well with practice in all the different examples on which it has been tested.

In those cases in which it does not agree, it is to be surmised that the practitioner has been misled by adherence to the erroneous theory alluded to above.

It will be noticed that, contrary to the view usually accepted, the length must be greater the slower the speed.

This is clearly correct; for the slower the speed the greater difficulty has the journal in dragging in its supply of oil to meet the required demand in opposition to the bearing pressure which is squeezing it out.

The lower must that bearing pressure accordingly be—i. e., the greater l for a given d, in order to enable the journal to maintain its oil film unbroken.

For a half-brass, p may be taken at about ¾ of the above values.

For oils with more body, however, the bearing pressure may be from 25 to 50 per cent. greater.

Factor of Safety.—The above calculated lengths are minimum values which cannot be diminished without rupture of the oil film. It will be better to have the lengths a little greater than these, so as to afford a reasonable factor of safety against such rupture. The pressures which were used in the calculations may therefore be called the critical pressures, since they specify those which must not be exceeded if we are to avoid the danger of running dry. We may properly define as the factor of safety of a given lubricated bearing the ratio of the critical pressure to the actual pressure under which it will work; or $n = p_c/p$.

It is clear also that the factor of safety is equal to the ratio of the length of journal actually adopted to the critical length as calculated above. Thus, suppose we have a journal of length l_o, diameter d_o running at N revolutions per minute, which is loaded with P lbs., and is just running at the critical pressure p_c. Then its terminal temperature is

$$\theta_t = \frac{(d_o N)^{\frac{1}{2}}}{4};$$

and the critical pressure at the given rubbing speed $\frac{\pi d_o}{12} N$ and this final temperature θ_t is

$$\left(\text{by formula } v_o = \frac{p\,\theta}{40}\right),\ p_c = 40\,(d_o N)^{\frac{1}{2}}$$

The friction work is greater when a factor of safety is secured by enlarging the journal diameter than it is when obtained by increasing the length.

THE SETTING OF PORTLAND CEMENT

By BERTRAM BLOUNT

CONDENSED FROM "CONCRETE AND CONSTRUCTIONAL ENGINEERRING"

Some years ago it was generally believed that all requisite knowledge of the setting of Portland cement had been acquired. It was supposed that the setting depended on the hydration of a calcium aluminate, to which the formula 3 CaO Al_2O_3 was assigned, and that the rapidity of setting depended on the proportion of this aluminate—the higher the proportion the quicker the setting. There were, of course, minor questions which required some sort of explanation, but with these axioms as a guide the expert found his path broad and plain.

At present the situation is by no means so simple. The belief that the essential constituent concerned in the setting of cement is an aluminate remains, but the identity of the aluminate is doubtful. The mechanism by which the aluminate sets is supposed to be the hydration of this substance, its dissolution to a supersaturated solution, the deposition of the surplus, the re-formation of a supersaturated solution, and so da capo. In addition to the doubt as the composition of the aluminate, there is no direct evidence of the aluminate forming a supersaturated solution. Futher, it is not easy to understand why a small amount of water, e. g., 1 per cent., absorbed by the cement during storage, capable of hydrating only a small proportion of the aluminate, can profoundly modify the time of setting as it does. Many other facts in connection with the setting of cement require explanation, among the most important being those dealing with the time of setting.

Two aspects of the setting time question need to be considered. The first is the inquiry: What are the chemical and physical causes

and operations which govern the process of setting? The question is of high scientific interest and much complexity, and cannot yet be answered; accurate data are almost completely lacking. Until detailed knowledge has been gained, generalization must be confined to some simple hypothesis as that given above, it being understood that it is no more than an hypothesis; in consequence of the limited value of a generalization so imperfect, each case of "anomalous" setting must be studied as an individual and on its merits.

The second aspect of the setting time question is practical. It is: How to insure that a cement procured for a given piece of work shall set suitably?

When it is considered that in ordinary construction the cement may be mixed in proportions varying from 1:1 to 1:12, may be handled in a time varying from a few minutes to an hour, and may be exposed to a load in a few days, it will be seen that the conditions are onerous. A cement to meet these conditions must remain inert for at least one hour; after that the quicker it sets the better. It remains to consider whether such a cement can be regularly made, and whether its quality can be properly tested before it is used.

Take the second and easier part of the question first. Clearly the ordinary methods of the testing room are insufficient. Three pats of neat cement, carefully gaged, kept at a known and uniform temperature, and protected from evaporation, are used to ascertain the setting time. In practice a mass of stone and sand mixed wholesale with the cement, mixture being aided by a liberal supply of water, is dumped into place under any sort of weather conditions which may prevail. The gap between the two procedures is too wide. A useful intermediate step would be to make blocks of concrete from the aggregate intended for use, and mixed, not with the precision of a skilled gager, but with that ordinary amount of skill and care which can be expected from a good laborer. Such a mode of testing, though rough, would be a guide to the behavior of the material in the work.

Next, the task of the manufacturer is to produce a cement which shall have a considerable period of quiescence after it has been mixed with water, and then set rapidly. Until the causes of setting are accurately known, the maker in producing such a cement must proceed empirically. In attempting his task he must remember what has been brought about by the conversion of cement manufacture from the fixed kiln to the rotary kiln process. In the old process there was a mixture of well-burnt clinker, relatively high in lime, with under-burnt material and material containing the ash of the fuel; the composition of these three substances differs substantially. In the present process the whole product is of the same composition. It is conceivable that the under-burnt material and the material containing the ash of the fuel, and relatively poor in lime, are the chief agents in determining the setting time of the cement and in influencing alteration of the setting time. As this adventitious material does not occur in rotatory clinker, the setting of rotatory cement depends upon the properties of those chemical compounds which constitute fully burnt clinker. In short, by the introduction of the rotatory kiln, Portland cement, almost as uniform as when made in the laboratory, has become an article of commerce. Differing from the mixed product from fixed kilns, its properties naturally differ and must be studied apart. It follows that methods of controlling setting time—e. g., by adding water, gypsum, or by storage, whose effects are fairly understood—though their rationale may not be—when they are applied to fixed kiln clinker, will give different results with rotatory clinker of the same mean composition. Experience shows that this expectation is warranted.

As long as our state of ignorance as to the mechanism of setting continues, progress must be empirical. Various devices, including the addition to clinker, which sets badly but hardens well, of some preparation which is of value merely for setting, are being and will be tried, and it is likely that some of these will prove effective. But until the chemistry of Portland cement is understood to a point when it is possible to assign to each constituent its true role, not merely alone, but in the presence of its fellows, unforeseen difficulties, paradoxical phenomena will be encountered, and explanations will be guesses or glosses.

Before the Commission can assess the environmental effects of the proposed Project, it must first determine whether the Project is likely to cause significant adverse environmental effects. If the Commission determines that the Project is likely to cause significant adverse environmental effects, it must then determine whether those effects are justified in the circumstances. In making these determinations, the Commission must take into account the factors set out in subsection 19(1) of the CEAA 2012.

THE ENVIRONMENTAL EFFECTS OF ACCIDENTS OR MALFUNCTIONS

Subsection 19(1)(f) of the CEAA 2012 requires the Commission to take into account the environmental effects of accidents or malfunctions that may occur in connection with the Project and the significance of those effects.

The Commission considers that the Project could result in accidents or malfunctions that could affect the environment. Such accidents or malfunctions could include, but are not limited to, a spill of crude oil or other substances, a fire, or a collision between a vessel and a marine mammal. The Commission considers that the likelihood of such accidents or malfunctions occurring is low, and that the environmental effects of such accidents or malfunctions would be significant.

The Commission considers that the Project's design, construction, operation, decommissioning and abandonment, and the mitigation measures that would be implemented, would reduce the likelihood of accidents or malfunctions occurring and would reduce the significance of their environmental effects. The Commission considers that the Project's emergency response plans would reduce the significance of the environmental effects of accidents or malfunctions that may occur in connection with the Project.

The Commission considers that the environmental effects of accidents or malfunctions that may occur in connection with the Project would be significant.

column stronger in its details than in the body, and at the same time give maximum crippling strength of the body.

Though the results obtained seem to indicate a wide range of variation, yet it is found that no less than ten of the nineteen columns tested form into five pairs in which the crippling loads of the members of each pair agree so closely that they satisfactorily establish each other's reliability.

The members tested comprised six posts and thirteen chords, pin ended, ranging in length from 13 ft. 7 5-16 ins. to 25 ft., with l/r (length / least radius of gyration) ratios of from 29 to 120, and of various sections built up from Z-bars, angles, channels and cover plates. Twelve of the members were constructed of wrought-iron sections, the remaining seven being of steel.

An examination of Mr. Buchanan's results reveals the fact that in every test the crippling load was considerably below the yield point of the metal. The yield points for the iron and steel used were 30,000 to 34,000 lbs. and 40,000 lbs. respectively. The crippling strength of the large columns tested, however, ranged only from 24,000 to 34,000 lbs. per sq. in., even though the series included columns so short that the "column reduction" effect was virtually eliminated.

Commenting on these tests "Engineering News" says editorially:

"Two things are clearly apparent: First, that the crippling loads reached only 90% of the yield point in the wrought-iron columns and only 80% in the steel columns; second, that the 'short' columns show no gain over the average. No rising tendency of the strength seems to accompany the low length-ratios, and it is reasonable to conclude that the results represent the limiting strength of such columns irrespective of any 'column reduction.'

"The general result may therefore be expressed thus: Well-made wrought-iron or steel columns fail completely at loads which on the most favorable assumption will not exceed 90% of the tensile yield point of the material. A steel column whose material shows 40,000 lbs. tensile yield point will, when loaded to 18,000 lbs. per sq. in., have a factor of safety of not over 2, even if its construction be of the best type. In contrast therewith, a tension member of the same material, loaded to 20,000 lbs. per sq. in., has a factor of safety against failure exceeding 3, while against permanent deformation it has a factor of 2, which is as great as the factor of safety of the column against final collapse.

"This is the most important showing of the tests recorded. It is a most impressive warning of the danger of that gradual increase in working stresses which has been quietly going on for eight or ten years past. In column design particularly, we are warned to return to more conservative practice.

"A study of the tabulated figures makes clear the fact that in the upper part of the range of column resistance there is a domain of imperfect elasticity, just as there is a similar domain in the upper range of tensile resistance. In tension tests this domain covers something more than the upper one-third of the ultimate—that is, the elastic range is not quite two-third of the ultimate strength. Judging from the results of Mr. Buchanan's tests, the domain of elastic behavior in column resistance extends little higher than two-thirds the collapsing strength.

"In conservative designing the intensities of permanent load and of repetitive loading must in all cases remain below the limit of elastic behavior. If this consideration be allowed to govern in fixing column stresses, we must take our limit not merely at 80% to 90% of the tensile yield point, as shown by the figures of crippling strength, but at 70% of this reduced value, or, say at 60% of the tensile yield point. We are then limited to about 21,000 to 24,000 pounds per square inch in steel, for the figures to be taken as the initial point in column calculations. Column reduction and the necessary margin of safety against uncertainties, imperfections, ignorance and service contingencies, will of course bring the practical working stresses to a value much lower."

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NEW REINFORCED CONCRETE REGULATIONS IN PHILADELPHIA

We give herewith, in slightly condensed form, the regulations of the Bureau of Building Inspection of Philadelphia in regard to the use of reinforced concrete, which were approved by Director Henry Clay, of the Department of Public Safety, on October 8, 1907.

The term "reinforced concrete" shall be understood to mean an approved concrete mixture reinforced by steel or iron of any shape, so that the steel or iron will take up all the tensional stresses and assist in the resistance to compression and shear.

Reinforced-concrete construction will be accepted for fireproof buildings of the first class, if designed as hereinafter prescribed; provided, that the aggregate for such concrete shall be clean, broken, hard stone, or clean graded gravel, together with clean siliceous sand or fine grained gravel; should the concrete be used for flooring between rolled steel beams, clean furnace clinkers entirely free of combustible matter, or suitable seasoned furnace slag may be used; when stone is used with sand gravel it must be of a size to pass through a 1-in. ring, and 25% of the whole must not be more than one-half the maximum size; and provided further, that the minimum thickness of concrete surrounding the reinforcing members of reinforced-concrete beams and girders shall be 2 ins. on the bottom and 1½ ins. on the sides of the said beams and girders. The minimum thickness of concrete under slab rods shall be 1 in. All reinforcement in columns to have a minimum protection of 2 ins. of concrete.

All the requirements herein specified for the protection of steel and for fire-resisting purposes shall apply to reinforced concrete flooring between rolled-steel beams as well as to reinforced-concrete beams and to entire structures in reinforced concrete. Any concrete structure or the floor filling in same, reinforced or otherwise, which may be erected on a permanent centering of sheet metal, of metal lathing and curved bars or a metal centering of any other form, must be strong enough to carry its load without assistance from the centering, unless the concrete is so applied as to protect the centering as herein specified for metal reinforcement.

Exposed metal centering or exposed metal of any kind will not be considered a factor in the strength of any part of any concrete structure, and a plaster finish applied over the metal shall not be deemed sufficient protection unless applied of sufficient thickness and properly secured, as approved by the Chief of the Bureau of Building Inspection.

All concrete shall be mixed in a mechanical batch mixer to be approved by the Bureau of Building Inspection, except when limited quantities are required or when the condition of the work makes hand mixing preferable; hand mixing to be done only when approved by the Bureau of Building Inspection. In all mixing the material shall be measured for each batch.

When hand mixing is done under the aforesaid limitations, the cement and fine gravel or coarse sand shall be first thoroughly mixed dry and then made into a mortar by gradually adding the proper amount of water. The crushed stone or gravel shall be spread out to a depth not to exceed 6 ins., in a tight box or upon a proper floor, and be sprinkled with water as directed; the mortar is then to be evenly spread over the crushed stone, and the whole mass turned over a sufficient number of times, to affect the thorough mixing of the ingredients.

All forms and centering for concrete shall be built plumb and in a substantial manner, made tight so that no part of the concrete mixture will leak out through cracks or holes, or joints, and after completion shall be thoroughly cleaned, removing shavings, chips, pieces of wood and other material, and no debris of any kind shall be permitted to remain in the forms. All forms to be properly supported and braced in a manner to safely sustain the dead load and the load that may be imposed upon them during construction.

The reinforcing steel shall be accurately located in the forms and secured against displacement.

Concrete shall be placed immediately after mixing.

Whenever fresh concrete joins concrete that is set, or partially set, the surface of the old concrete shall be roughened, cleaned and spread

with cement mortar, which mortar shall be mixed in proportions of one of cement to two of sand.

Concrete shall not be mixed or deposited in freezing weather, unless precautions are taken to avoid the use of material covered with ice or snow or that are in any other way unfit for use, and that further precautions are taken to prevent the concrete from freezing after being put in place. All forms under concrete so placed to remain until all evidences of frost are absent from the concrete and the natural hardening of the concrete has proceeded to the point of safety.

Concrete laid during hot weather shall be drenched with water twice daily, Sunday included, during the first week. The broken stone, if hot and dry, must be wet before going to the mixer.

The time at which props or shores may safely be removed from under floors and roofs will vary with the condition of the weather, but in no case should they be removed in less than two weeks; provided, that column forms shall not be removed in less than four days; provided further, that the centering from the bottom of slabs and sides of beams and girders may be removed after the concrete has set one week, provided that the floor has obtained sufficient hardness to sustain the dead weight of the said floor and that no load or weight shall be placed on any portion of the construction where the said centers have been removed.

The concrete for all girders, beams, slabs and columns, shall be mixed in the proportions of one of cement, two of sand or fine gravel and four of other aggregates as before provided. The concrete used in reinforced concrete-steel construction must be what is usually known as a "wet" mixture. When the concrete is placed in water it must be placed in a semi-dry state.

Only Portland cement shall be permitted in reinforced concrete constructed buildings. All cement shall be tested, in carload lots when so delivered or in quantities equal to same, and report filed with the Bureau of Building Inspection before using it in the work. Cement failing to meet the requirements of the accelerated test will be rejected.

Soundness of Cement: Accelerated Test.—Pats of neat cement will be allowed to harden 24 hours in moist air, and then be submitted to the accelerated test as follows: A pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely-closed vessel, for 3 hours, after which, before the pat cools, it is placed in the boiling water for 5 additional hours.

To pass the accelerated test satisfactorily, the pats shall remain firm and hard, and show no signs of cracking, distortion or disintegration.

Such cements, when tested, shall have a minimum tensile strength as follows: Neat cement shall, after one day in moist air, develop a tensile strength of at least 150 lbs. per sq. in.; and after one day in air and six days in water shall develop a tensile strength of at least 500 lbs. per sq. in.; and after one day in air and 27 days in water shall develop a tensile strength of at least 600 lbs. per sq. in. Cement and sand tests composed of one part of cement and three parts of crushed quartz shall, after one day in air and six days in water, develop a tensile strength of at least 175 lbs. per sq. in., and after one day in air and 27 days in water shall develop a tensile strength of at least 240 lbs. per sq. in. These and other tests as to fineness, set, etc., made in accordance with the standard method prescribed by the American Society of Civil Engineers, may, from time to time, be required by the Bureau of Building Inspection.

Walls.—Reinforced concrete may be used in place of brick and stone walls, in which cases the thickness may be two-thirds of that required for brick walls as shown in the Schedule, Section 18 of the Act of Assembly No. 123, of the Commonwealth of Pennsylvania, approved June 5, 1901, provided the unit stresses as set forth in these regulations are not exceeded.

Concrete walls in such cases must be reinforced in both directions in a manner to meet the approval of the Chief of the Bureau of Building Inspection.

Steel. All reinforcements used in reinforced concrete shall be of standard grade of structural steel or iron of either grade to meet the "Manufacturers' Standard Specifications," revised February 3, 1903.

Reinforced-concrete slabs, beams and girders shall be designed in accordance with the following assumptions and requirements:

(a) The common theory of flexure to be applied to all beams and members resisting bending.

(b) The adhesion between the concrete and the steel is sufficient to make the two materials act together.

(c) The design shall be based on the assumption of a load four times as great as the

total load (ordinary dead load plus ordinary live load).

(d) The steel to take all the tensile stresses.

(e) The stress-strain curve of concrete in compression is a straight line.

(f) The ratio of the modulus of elasticity of concrete to that of steel:

Stone or gravel concete .....1 to 12
Slag concrete .....1 to 15
Cinder concrete .....1 to 30

The allowable unit transverse stress upon concrete in compression:

Stone or gravel concrete....600 lbs. per sq. in.
Slag concrete .....400 " "
Cinder concrete .....250 " "

The allowable unit transverse stress in tension:

Iron .....12,000 lbs. per sq. in.
Steel .....16,000 " "

The allowable unit shearing strength upon concrete.

Stone or gravel concrete ....75 lbs. per sq. in.
Slag concrete .....50 " "
Cinder concrete .....25 " "

The allowable unit adhesive strength of concrete:

Stone or gravel concrete....50 lbs. per sq. in.
Slag concrete .....40 " "
Cinder concrete .....15 " "

The allowable unit stresses upon concrete in direct compression in columns:

Stone or gravel concrete ...500 lbs. per sq. in.
Slag concrete .....300 " "
Cinder concrete .....150 " "

The allowable unit stress upon hoop columns composed of stone or gravel concrete shall not be over 1,000 lbs. per sq. in., figuring the net area of the circle within the hooping. The percentage of longitudinal rods and the spacing of the hoops to be such as to permit the concrete to safely develop the above unit stress with a factor of safety of four.

When steel or iron is in the compression sides of beams the proportion of stress taken by the steel or iron shall be in the ratio of the modulus of elasticity of the steel or iron to the modulus of elasticity of the concrete provided that the rods are well tied with stirrups connecting with the lower rods of the beams; provided, further, that when rods are used in compression, the approval of the Chief of the Bureau of Building Inspection must be obtained.

In the design of structures involving reinforced concrete beams and girders, as well as slabs, the beams and girders shall be treated as T-beams, with a portion of the slab acting as flange in each case. The portion of the slab that may be used to take compression shall be dependent upon the horizontal shearing stress that may exist in the beam, and in no case shall the slab portion exceed twenty times the thickness of the slab.

All reinforced concrete T-beams must be reinforced against the shearing stress along the plane of junction of the rib and the flange, using stirrups throughout the length of the beam. Where reinforced concrete girders carry reinforced concrete beams, the portion of the floor slab acting as flange to the girder must be reinforced with bars near the top, at right angles to the girder, to enable it to transmit local loads directly to the girder and not through the beams, thus avoiding an integration of compressive stresses due to simultaneous action as floor slab and girder flange.

In the execution of work in the field, work must be so carried on that the ribs of all girders and beams shall be monolithic with the floor slabs.

In all reinforced concrete structures special care must be taken with the design of joints to provide against local stresses and secondary stresses due to the continuity of the structures.

Shrinkage and thermal stresses shall be provided for by the introduction of steel.

In the determination of bending moments due to the external forces, beams and girders shall be considered as simply supported at the ends, no allowance being made for continuous construction over supports. Floor slabs, when constructed continuously, and when provided with reinforcement at top of slab over the supports, may be treated as continuous beams, the bending moment for uniformly distributed loads being taken at not less than WL/10 in cases of square floor slabs which are reinforced in both directions and supported on all sides, the bending moment may be taken at WL/20; provided, that in floor slabs in juxtaposition to the walls of the building the bending moment shall be considered as WL/8, when reinforced in one direction, and if the floor slab is square and reinforced in both directions, the bending moment shall be taken as WL/16.

When the shearing stresses developed in any part of a reinforced concrete building exceed under the multiplied loads the shearing strength as fixed in this section, a sufficient amount of steel shall be introduced in such a position that the deficiency in the resistance to shear is overcome.

When the safe limit of adhesion between the concrete and steel is exceeded, provision must be made for transmitting the strength of the steel to the concrete.

Reinforced concrete may be used for columns in which the ratio of the length to least side or diameter does not exceed 15. If more than 15 diameters the allowable stress shall be decreased proportionally. Reinforcing rods that are introduced for lateral stresses must be tied together at intervals of not more than the least side or diameter of the columns.

Longitudinal reinforcing rods will not be considered as taking any direct compression.

The contractor must be prepared to make load tests in any portion of a reinforced concrete building within a reasonable time after erection and as soon as may be required by the Chief of the Bureau of Building Inspection. The tests must show that the construction will sustain a load equal to twice the calculated live load without signs of cracks.

Systems of construction differing from the standard already approved and tested may be required to pass a load, fire and water test, as presented in Section 2 of the Act of Assembly, No. 236, of the Commonwealth of Pennsylvania, approved April 25, 1903.

STRENGTH OF RIVETED JOINTS

By J. C. BLACK

CONDENSED FROM THE "CALIFORNIA JOURNAL OF TECHNOLOGY"

The results of a series of tests recently made at the Civil Engineering Laboratory of the University of California demonstrated the effect, if any, of certain features of riveted work which are commonly considered defects.

The series of tests included (1) Well-made joints having punched and reamed holes; (2) joints having holes punched without reaming; (3) joints in which the heads of rivets were cooler than customary when driven; (4) joints in which the heads were hotter than customary when driven; (5) joints in which the pressure on rivets was maintained longer than usual; (6) joints containing burned rivets, the rivets having been heated in the forge until they "spit" upon removal, then carried to riveting room and placed in regular petroleum heater; (7) one joint having extra large holes; (8) joints having holes eccentric. All plates were of ½-in. Carnegie "tank steel;" rivets were ¾-in. soft steel of Carnegie manufacture. Except in (7) the holes were 13/16 in. in diameter. Riveting was done with an Allen pneumatic riveter. The fact that specimens were small and were held by hand while riveted, may have had the effect of reducing the quality of the work, since in large work the plates are held stationary and thus afford better opportunity for a direct blow from the machine. In general, rivets were driven by a single blow, and the pressure was maintained for only an instant.

Rivets were heated in a petroleum heater; scale was knocked from all before driving—a practice which is not always followed in ordinary work. Only lap joints were used, and each contained two rivets, although there were two designs or types of joint—the first being in the nature of a single-riveted lap joint, see figure 1, 2¾ ins. c. to c. of rivets; and the second having the pitch line of rivets in the direction of stress 2½ ins. c. to c. of rivets. All joints were designed to fail in the rivets, although in some cases the plate itself gave way, at a point very near to what should have been the ultimate strength of the rivets. The edges of all joints were planed off near the center to allow the proper attachment of brackets for deformation measurements. In the first type of joint holes were drilled in each edge of each plate just opposite the rivets, and the holes were tapped to receive a number 8 screw. In the second type holes were drilled midway between rivets and were tapped as before.

The tests were made in the 200,000-lb. Olsen machine, and deformations were measured with an Olsen compressometer. After the joint had been clamped in the jaws, and the planed edges brought into a vertical position, brackets were screwed to the edges. Each bracket contained a small, accurately finished brass plug, and upon which the points of the compressometer arms rested.

Loads were applied in increments of 1,000 or 2,000 lbs., and the test carried to failure without stopping the machine except in the special cases noted. Each joint behaved in

a very satisfactory manner. Many of the specimens bent to a certain extent before failure. Rivet failure was always in shear, giving silky fracture.

The results of the series of tests may be summed up under seven heads. There are no positive proofs of the various points, but the indications are as follows:

First. That the strength of rivets in a joint having holes punched without reaming is greater, rather than less, than in one in which holes are punched small and reamed to size.

Second. That the exact temperature of the rivet or of a particular part of it is immaterial to the strength of the joint.

Third. That a maintenance of pressure for 30 seconds materially increases both the strength and rigidity of the joint—the first sometimes by as much as 40%.

Fourth. That rivets burned so that they spit when taken from the fire do not necessarily cause a weakness in the joint although they do not properly fill their holes.

Fifth. That a rivet 3/16 in. smaller than the hole which it is to fill, will fill the space tolerably well, though not perfectly.

Sixth. That joints in which the holes are not perfectly concentric lack rigidity, but give ultimate strengths about up to standard.

Seventh. That the shearing value of a rivet is materially greater after driving than before, this probably being due to increased cross section.

SUPERHEATED STEAM

FROM "THE ENGINEER," LONDON

No engineer possessing a fair knowledge of the steam engine disputes that less superheated than saturated steam is required to develop a horse-power per hour. The problem for the dispassionate outsider lies in the fact that, in spite of this admission, the superheater remains we fear we must say unpopular. There must be some reason for this.

In the first place, a great deal of uncertainty on vital points exists. Thus, for example, there is no consensus of opinion as to why superheated steam is more economical than saturated steam. We are told, on the one hand, that there is no thermodynamic reason why it should be better, save one, that it keeps the cylinder hot, and so prevents initial condensation. On the other hand, it is affirmed with equal confidence that initial condensation is a delusion; it does not occur; it cannot, for excellent reasons, occur. The missing quantity is simply leakage, and superheating is economical because it prevents leakage. The perplexed steam user asks why a valve should pass saturated steam and not superheated steam, but he never receives an explanation. Again, he wants to know if it is really possible that in a good, well-kept engine, the valves of which are absolutely tight while the engine is at rest, no less than 30 or 40% of all the steam going into the engine will leak past them? Very naturally he is incredulous. "But," he reasons, "if this is true, instead of going in for superheating with its various risks, why not make my engine valves tight? That cannot be impossible." Again, he is assured on the one hand that nothing more is required than to superheat the steam, say 50°, so as to be sure that it is dry; and, on the other, that to make superheating worth its initial cost, the steam ought to be nearly red-hot. Who is right? Nor does he find himself on safer ground when he has to determine between the conflicting claims of different superheating systems. Shall he use small pipes or large pipes? Will the waste heat from his boilers do, or must he put up a separate furnace? If he uses the waste heat what becomes of his feed-water? Is that to go cold into the boilers? No definite convincing reply is to be had. The price to be paid for superheating plant at the outset, and for its maintenance, is another vexed question. It is not wonderful, we think, that progress is slow.

Professor Mellanby, in a discussion held at the West of Scotland Iron and Steel Institute, on a paper which he had previously presented, pointed out that even with a superheat of only 200° engines have to be very carefully watched. As to higher temperatures, he directed attention to a paragraph in his paper in which he had shown that the thermodynamic gain from superheating was comparatively small, and its chief advantage that it reduced the missing quantity. In this we concur; but we do not concur when he maintains that the

missing quantity is due to valve leakage. He concluded with the following words: "It is indeed remarkable that practically all our treatises persist in regarding steam engines as being absolutely free from this leakage, whilst they do not hesitate to attribute enormous initial condensation losses to them in order to account for their measured consumption. I am sure that when once this possibility of valve leakage is fully recognized by writers and experimenters there will at last be a probability of producing a reasonable theory of the steam engine."

There are at the present moment just three men who have adopted the valve leakage theory in its complete form; these are Messrs. Callendar, Nicolson and Mellanby. Others admit, as a matter of course, that slide valves leak, but this leakage is for all engines worth taking into account quite exceptional. We venture to say that the theory is based on evidence much too slight and too narrow to possess scientific value. We are glad that Professor Mellanby admits that for which we have long contended—the desirability of framing a reasonable theory of the steam engine. It ought, we think, to have already struck Professor Mellanby that it is the manifest duty of those who have advanced a novel proposition to proceed to prove at least its general accuracy. It is a suggestive fact that engines with drop valves, which presumably do not leak, have a missing quantity quite as large as that in slide-valve engines, and that they derive at least as much benefit from superheating as does any good slide or piston valve engine. The reply to this argument does not appear to have yet been discovered.

STEAM-DRIVEN ELECTRIC POWER PLANT COSTS†

COSTS OF STEAM TURBINE AND RECIPROCATING ENGINE POWER PLANTS PER KW. CAPACITY.

	Turbine plants.		Reciprocating engine plants.	
Excavations and foundations.	$2.00	$2.50	$3.00	$5.00
Building	10.00	15.00	10.00	20.00
Tunnels (condenser water conduit)	1.75	4.00	1.50	2.75
Flues and stacks	2.50	3.50	2.50	3.50
Boilers and stokers	8.50	12.00	8.50	12.00
Superheaters	2.00	2.50	1.75	2.25
Economizers	2.00	2.25	2.00	2.25
Coal & ash handling systems	1.50	3.00	1.50	3.00
Blowers and ducts	1.00	1.50	1.00	1.50
Pumps and tanks	1.00	1.25	1.00	1.25
Piping systems	2.25	4.50	2.50	5.00
Turbo-generators (engines).	22.00	25.00	18.00	22.00
Condensers*	5.00	8.00	3.00	5.00
Exciters	.75	1.00	.75	1.00
Crane	.25	.50	.25	.50
Switchboards	2.00	3.50	2.00	3.50
Plumbing, painting, labor, etc.	1.00	2.00	1.00	2.00
Generators	....	....	10.00	12.00
	$65.50	$92.00	$70.25	$104.50

*Surface condensers for turbine plants; jet condensers for reciprocating engine plants.

To these summarized costs there needs still to be added the engineering fee which in many cases is figured as a percentage on the total cost.

It should be noted that the first and third columns of figures in the table represent costs which are exceptionally low and may be attained under favorable conditions with engineering skill. The second and fourth columns of figures represent fair average figures as ascertained from the costs of a number of plants recently erected. However, plants have been installed which cost as much as $92 per KW. The main items constituting cost approximated $150 per KW.

All of these figures represent costs of plants of large capacity. Small plants of about 3,000 KW. capacity have been erected in the West at from $120 to $130 per KW., which costs may be reduced if a simple combination of machines is provided.

Referring to the table, it will be observed that the turbine plant varies from $65 to $92 per KW. The main items constituting this difference are: building turbo-generators and condensers. The difference in cost of these is due to the type of turbine, the size and make of condensers and their auxiliaries, as well as the manner of assembling, all of which may reduce the size of the building required.

The difference in cost of boilers is due to the make or type and the rating of the boiler horse-power adopted by the plant designer per KW. capacity. This ratio varies greatly. Plants have been installed with the same type of boiler and the same type of prime mover in which the ratio varies, one value being 0.60 boiler horse-power per KW. generator capacity, while in other cases it is 0.75 and 0.80. This difference depends upon the experience and judgment on the part of the designer as well as the estimated ability of the future available operating force to produce steam effectively.

The difference observed in the cost of the other items may be explained by the difference in the grade of material used and the ability of one purchaser over another to secure the lowest market price.

†Frank Koester, in "Engineering News."

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POWER TRANSMISSION BY FRICTION DRIVING*

By W. F. M. GOSS†

A friction drive consists of a fibrous or somewhat yielding driving wheel working in rolling contact with a metallic driven wheel. Such a drive may consist of a pair of plain cylindered wheels mounted upon parallel shafts, or a pair of beveled wheels, or of any other arrangement which will serve in the transmission of motion by rolling contact. The use of such drives has steadily increased in recent years, with the result that the so-called paper wheels have been improved in quality and a considerable number of new materials have been proposed for use in the construction of fibrous wheels.

Choosing materials which have been used for such purposes, driving wheels of each of the following materials have been tested: Straw fiber, straw fiber with belt dressing, leather fiber, leather, leather-faced iron, sulphite fiber, tarred fiber. Each of the fibrous driving wheels was tested in combination with driven wheels of the following materials: Iron, aluminum, type metal.

The straw-fiber wheels are worked out of blocks which are built up usually of square sheets of straw board laid one upon another with a suitable cementing material between them and compacted under heavy hydraulic pressure. In the finished wheel the sheets appear as disks, the edges of which form the face of the wheel. The material works well under a tool but it is harder and heavier than most woods and takes a good superficial polish.

The wheel of straw fiber with belt dressing was similar to that of straw fiber, except that the individual sheets of straw board from which it was made had been treated, prior to their being converted into a block, with a "belt dressing," the composition of which is unknown to the writer.

The leather-fiber wheel was made up of cemented layers of board, as were those already described; but in this case the board, instead of being of straw fiber, was composed of ground sole-leather cuttings, imported flax and a small percentage of wood pulp. The material is very dense and heavy.

The leather wheel was composed of layers of disks of sole leather.

The leather-faced iron wheel consisted of an iron wheel having a leather strip cemented to its face. After less than 300 revolutions the bond holding the leather face failed and the leather separated itself from the metal of the wheel. This wheel proved entirely incapable of transmitting power and no tests of it are recorded.

The wheel of sulphite fiber was made up of sheets of board composed of wood pulp. The sulphite board is said to have been made on a steam-drying continuous-process machine in the same way as is the straw board.

The tarred-fiber wheel was made up of board composed principally of tarred rope stock, imported French flax and a small percentage of ground sole-leather cuttings.

From the experiments made it appears that those driving wheels which are the more dense work more efficiently with the iron follower than with either the aluminum or type-metal followers; but in the case of the softer and less dense driving wheels, and especially in the case of those in which an oily substance is incorporated, driven wheels of aluminum and type metal are superior to those of iron. Finely powdered metal which is given off from the surface of the softer metal wheels seems to account for this effect, and the character of the driving wheels is perhaps the only factor necessary to determine whether its presence will be beneficial or detrimental. Finally, with reference to the use of soft-metal driven wheels, it should be noted that no combination of such wheels with a fibrous driver appears to have given high frictional results. Except when used under very light pressures, the wear of the type metal was too rapid to make a wheel of its material serviceable in practice.

In regard to the relative value of the different fibrous wheels when employed as drivers in a friction drive, the results show at

*From a paper presented to the American Society of Mechanical Engineers, December, 1907.

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once that the addition of belt dressing to the composition of a straw-fiber wheel is fatal to its frictional qualities. The highest frictional qualities are possessed by the sulphite-fiber wheel which, on the other hand, is the weakest of all wheels tested. The leather fiber and tarred fiber are exceptionally strong; and the former possesses frictional qualities of a superior order. The plain straw fiber, which in a commercial sense is the most available of all materials dealt with, when worked upon an iron follower possesses frictional qualities which are far superior to leather, and strength which is second only to the leather fiber and the tarred fiber.

The results of these experiments do not furnish an absolute measure of the most satisfactory pressure of contact for service conditions. Other things being equal, the power transmitted will be proportional to this pressure and hence it is desirable that the value be made as high as practicable. On the other hand, it has been noted as one of the observations of the test that as higher pressures are used, there appears to be a gradual yielding of the structure of the fibrous wheels; and it is reasonable to conclude that the life of a given wheel will in a large measure depend upon the pressure under which it is required to work. After careful study it has been determined to base an estimate of the power which may be transmitted upon a pressure of contact which is 20% of the ultimate resistance of the material as established by the crushing tests already described. This basis gives the following results:

SAFE WORKING PRESSURES OF CONTACT.

	Pressure.
Straw fiber	150
Leather fiber	240
Tarred fiber	240
Sulphite fiber	140
Leather	150

The coefficient of friction for all wheels tested approaches its maximum value when the slip between driver and driven wheel amounts to 2% and, within narrow limits, its value is practically independent of the pressure of contact. In view of these facts, it is proposed to base a measure of the power which may be transmitted by such friction wheels as those tested upon the frictional qualities developed at a pressure of 150 lbs. per inch of width, when operating under a load causing 2% slip. For safe operation, however, deductions must be made from the observed values. Thus, the results of the experiments disclose the power transmitted from wheel to wheel, while in the ordinary application of friction drives some power will be absorbed by the journals of the driven axle so that the amount of power which can be taken from the driven shaft will be somewhat less than that transmitted to the wheel on said shaft. Again, under the conditions of the laboratory, every precaution was taken to keep the surfaces in contact free of all foreign matter. It was, for example, observed that the accumulation of laboratory dust upon the surfaces of the wheels had a temporary effect upon the frictional qualities of the wheels, and friction wheels in service are not likely to be as carefully protected as were those in the laboratory. In view of these facts, it has been thought proper to use as the basis from which to determine the amount of power which may be transmitted by such wheels as those tested, a coefficient of friction which shall be 60% of that developed under the conditions of the laboratory. This basis gives the following results:

TABLE GIVING WORKING COEFFICIENTS OF FRICTION (60% OF ACTUAL VALUES) AND EQUATIONS FOR HORSE-POWER.

	Coefficient of friction.	Horse-power.
Straw fiber and iron	0.255	0.00030 dWN
Straw fiber and aluminum	0.273	0.00033 dWN
Straw fiber and type metal	0.186	0.00022 dWN
Leather fiber and iron	0.309	0.00059 dWN
Leather fiber and aluminum	0.297	0.00057 dWN
Leather fiber and type metal	0.183	0.00035 dWN
Tarred fiber and iron	0.150	0.00029 dWN
Tarred fiber and aluminum	0.183	0.00035 dWN
Tarred fiber and type metal	0.165	0.00031 dWN
Sulphite fiber and iron	0.330	0.00037 dWN
Sulphite fiber and aluminum	0.318	0.00035 dWN
Sulphite fiber and type metal	0.300	0.00034 dWN
Leather and iron	0.135	0.00016 dWN
Leather and aluminum	0.216	0.00026 dWN
Leather and type metal	0.246	0.00029 dWN

Having now determined a safe working pressure of contact and a representative value for the coefficient of friction, it is possible to formulate equations expressing the horse-power which may be transmitted by each combination of wheels tested. Thus, calling d the diameter of the friction wheel in inches, W the width of its face in inches and N the number of revolutions per minute, the equations are as given in the accompanying table.

A fibrous driving wheel, acting upon the face of a metal disk, constitutes a form of friction gear which is serviceable for a variety of purposes. If the driver is so mounted that it may be moved across the face of the disk, the velocity ratio may be varied and the direction of the disk's motion may be reversed. The contact is not one of pure rolling. If the driver is cylindrical in form, the action along

its line of contact with the disk is attended by slip, the amount of which changes for every different point along the line. The recognition of this fact is essential to a discussion of the power-transmitting capacity of the device.

Experiments involving the spur form of friction wheels already described have shown that slip greatly affects the coefficient of friction; that the coefficient approaches its maximum value when the slip reaches 2%, and that when the slip exceeds 3%, the coefficient diminishes. It is known that reductions in the value of the coefficient with increments of slip beyond 3% are at first gradual, although the characteristics of the testing machine have not permitted a definition of this relation for slip greater than 4%. The experiments, however, fully justify the statement that for maximum results the slippage should not be less than 2% nor more than 4%. It is the maximum limit with which we are concerned in considering the amount of power which may be transmitted by face friction gearing.

From the discussion of the previous paragraph, it should be evident that, for best results, the width of face of the friction driver and the distance between the driver and center of disk should always be such that the variations in the velocity of the particles of the disk having contact with the driver will not exceed 4%. A convenient rule, which if followed, will secure this condition, is to make the minimum distance between the driver and the center of the driven disk, twelve times the width of the face of the driver. For example, a driver having a ¼-in. width of face should be run at a distance of 3 ins. or more from the center of the disk.

It may not infrequently happen that friction wheels must be run nearer the center of the disk than the distance specified; there is, of course, no objection to such practice, but it should not be forgotten that as the center of the disk is approached, the coefficient of friction, and consequently the capacity to transmit power, diminishes.

Whatever may be the form of the transmission, the fibrous wheel must always be the driver. Neglect of this rule is likely to result in failure which will appear in the unequal wear of the softer wheel, occasioned by slippage.

The rolling surfaces of the wheel should be kept clean. Ordinarily they should not be permitted to collect grease or oil, nor be exposed to excessive moisture. Where this cannot be prevented, a factor of safety should be provided by making the wheels larger than normal for the power to be transmitted.

Since the power transmitted is directly proportional to the pressure of contact, it is a matter of prime importance that the mechanical means employed in maintaining the contact be as nearly as possible inflexible. For example, arrangements of friction wheels which involve the maintenance of contact through the direct action of a spring have been found unsatisfactory, since any defect in the form of either wheel introduces vibrations which tend to impair the value of the arrangement. It is recommended that springs be avoided and that contact be secured through mechanism which is rigid and which when once adjusted shall be incapable of bringing about any release of the pressure to which it is set.

THE MUSHROOM SYSTEM OF REINFORCED CONCRETE

By C. A. P. TURNER*

CONDENSED FROM "THE CANADIAN ENGINEER."

In his treatise on "Reinforced Concrete Construction," Chas. F. Marsh makes these interesting observations: "When properly combined with metal, concrete appears to gain properties which do not exist in the material when by itself, and although much has been done by the various experimenters in recent years to increase our knowledge on the subject of elastic behavior of reinforced concrete, we are still very far from having a true perception of the characteristics of the composite material.

*Inventor, M. Am. Soc. C. E., Minneapolis.

Figure 10 Reconstruction of a Greek hoplite phalanx in battle. Note the overlapping shields and the spears projecting from the second rank. Drawing by Peter Connolly.

Greek hoplite phalanx in battle. Note the overlapping shields and the spears projecting from the second rank. Drawing by Peter Connolly.

Figure 11 Reconstruction of a Greek hoplite phalanx in battle. Note the overlapping shields and the spears projecting from the second rank. Drawing by Peter Connolly.

Greek hoplite phalanx in battle. Note the overlapping shields and the spears projecting from the second rank. Drawing by Peter Connolly.

Figure 12 Reconstruction of a Greek hoplite phalanx in battle. Note the overlapping shields and the spears projecting from the second rank. Drawing by Peter Connolly.

Greek hoplite phalanx in battle. Note the overlapping shields and the spears projecting from the second rank. Drawing by Peter Connolly.

THE HISTORY OF CYANIDATION*

By PHILIP ARGALL

About two hundred years ago the chance manipulation of impure chemicals by Diesbach, a Berlin color manufacturer, resulted in the formation of ferric ferrocyanide or prussian blue—the first cyanogen compound known. This chance discovery of a new compound and a new color, while of the first importance to Diesbach, was none the less prophetic of the yet undiscovered cyanide compounds which have since revolutionized more than one industry, and added mightily to the gold production of the world.

The simple production of prussian blue was distinctly epoch-making, and rightly takes rank among the greatest of chemical discoveries, if measured only by the present usefulness of the cyanogen compounds in the metallurgy of gold. At the time prussian blue was discovered in 1704 indigo was the only blue coloring matter known, and so we find Diesbach and his partner, Dippel, an alchemist, were quite early engaged in the manufacture of this new and beautiful cyanogen compound. In 1710 Dippel presented a paper to the Academy of Berlin calling attention to the new compound, without, however, disclosing the method of its preparation. Fourteen years later Woodward, an English chemist and Fellow of the Royal Society, not only succeeded in making prussian blue, but also made public the method of its preparation, and it is interesting to note that this method of Woodward's is practically the process by which prussian blue is prepared today. Macquer, in 1752, observed that when prussian blue is boiled with caustic potash, oxide of iron remains, whilst a peculiar salt enters into solution which was named phlogisticated alkali, or yellow prussiate of potash. This body was shown to contain iron and prussic acid by Berthollet in 1787.

The actual composition of prussian blue was not known until 1782, when Scheele, 78 years after its discovery, obtained an acid from it which, in consequence he named "prussic acid," but even then the composition of the acid was not known. Prussic acid, hydrocyanic acid, or nitride of formic acid (CNH) occurs in certain plants, as for example, in laurel leaves, peach leaves, and in kernels of several kinds of stone fruit. The acid, however, was first obtained in the pure state by Gay Lussac in 1811, while four years later the same chemist discovered the radical cyanogen and showed that it was capable of existing in the free state. Hydrocyanic acid is said to have been known to the Egyptian priests and used by them to kill traitors.

Cyanide of potassium was first made by the simple fusion of yellow prussiate of potash and ferrocyanide of potassium in iron crucibles; when this operation is properly conducted the result is a mixture of carbide of iron and cyanide of potassium, the former adhering to the sides of the crucible, the latter in the midst of the mass. With a view to remedying certain objections to the foregoing process, Liebig proposed the ignition of dry ferrocyanide in the presence of dry potassium carbonate. At present much of the cyanide of potassium used in cyanidation of ores is produced by the Erlenmeyer process, which is based upon the action of sodium on ferrocyanide of potassium according to the reaction:

$$Fe(CN)_6K_4 + Na_2 = Fe + 4(KCN)\ 2(NaCN)$$

The resulting product is next treated with water, the solution evaporated, and the salt sold as 98% potassium cyanide, but it is really a mixture of 4 molecules of potassium cyanide in a solution of potassium cyanide.

With the introduction of the aniline colors, prussian blue found but a limited use in the arts, while cyanide, formerly of limited application in medicine, photography, electroplating, and as a laboratory reagent, has, since the cyanide process was established on a full scale, been used in greater quantities than any of the cyanide compounds, even now over one-half the potassium ferrocyanide produced is used in the manufacture of potassium cyanide.

Since cyanogen, really a nitride of carbon, greatly resembles the halogens, chlorine, bromine, and iodine, all of which dissolve gold, as do also some of their compounds, it was but a natural inference that cyanide of potassium would dissolve gold, as pointed out by Hagen in 1806. Of the various cyanogen com-

*Condensed from a paper read before the Colorado Scientific Society on November 2, 1907, and reprinted from the "Mining and Scientific Press."

pounds, I shall now confine myself to potassium cyanide (KCN) and endeavor to show in a casual way the development of this salt as a gold solvent on a practical scale.

It is reported that Dr. Wright, of Birmingham, England, used gold cyanide solutions for electroplating as early as 1840, in consequence of his investigations following the publication of Scheele's report on the solubility of gold cyanide in a solution of potassium cyanide. The brothers J. R. and H. Elkington made the first practical application of potassic cyanide as a gold solvent, and patented it in 1840, in connection with the electro-deposition of gold from cyanide solutions, though the application does look somewhat closely related to Dr. Wright's process above mentioned.

The Elkington solution was made by dissolving salts of gold in potassium cyanide; in their arrangement the articles to be gilded form a cathode, a plate of gold the anode, both immersed in the cyanide bath. The gold as deposited on the article to be gilded was dissolved from the gold anode plate, thus keeping the auro-potassic cyanide bath of about the same strength; here we see that a solution of potassium cyanide, plus electricity, was at this early date (1840) a known and recognized commercial gold solvent, and with but slight modifications it is so used in electroplating today.

In 1843 the Russian Prince Bagration, while investigating the Elkingtons' process, discovered that cyanide can dissolve gold without the aid of electricity. It is said that in the course of his researches he poured some cyanide solution into a gilded vessel and on emptying the vessel some time later found the gold plating had been removed from the sides and bottom. After a thorough examination Bagration reached the following conclusion, which not only stands good today, but also quite fairly sums up our general knowledge of the action of potassium cyanide on gold:

First, that cyanide of potassium will dissolve metallic gold; second, that if the gold is very fine it will pass rapidly into solution; third, that the electric current did not in the least help the solvent action of the solution of the gold; fourth, that heat greatly assisted the solution of the gold; that gold in cyanide solution can be precipitated on metallic surfaces without the aid of electricity; and lastly, that the air has a very marked action in quickening the solution of gold in cyanide solutions.

From this time progress was rapid. In 1844 Elsner showed that oxygen was necessary in connection with the use of cyanide as a solvent. In 1857 Faraday made quantitative determinations regarding the amount of gold leaf dissolved by solutions of cyanide and the rate of solution. Wurtz in 1866 showed that weak solutions could be used in dissolving gold. Following Wurtz, Rae, Clark, Fawcett and Saunders made further discoveries. In 1885 Simpson of Newark, N. J., patented a process for obtaining gold from ores by using cyanide. In 1887 the first MacArthur-Forrest patent was taken out. Other patents were taken out by MacArthur and Forrest in America and in Germany. Considerable litigation over the validity of the patents resulted, and the decisions of the courts were unfavorable to the patentees.

The MacArthur-Forrest process consists of neutralizing the acidity in a given ore with an alkali, dissolving the precious metals with dilute solution of potassium cyanide, and precipitating the gold on filiform zinc. The modifications of this process are numerous. The patent of J. C. Montgomery of Scotland, July, 1892, employed sodium or potassium dioxide as an oxidizing agent in conjunction with caustic soda. The points provided for here were the furnishing of more oxygen and having a strong alkaline solution, as such solutions are more active than plain cyanide and water. In the Kendall process of 1892 the action of cyanide is quickened by means of ferrocyanide of potassium; here an attempt is made to hasten the action of the cyanide as well as at the same time conserve its strength; the evolution of nascent cyanogen is probably also introduced for the first time as a feature of the process, imitating, no doubt, the evolution of nascent chlorine in another process, which is well known to greatly augment the dissolution of gold.

Almarin B. Paul originated wet crushing with cyanide solution in the batteries at the Calumet mill, Shasta county, California.

Wet crushing with cyanide solution in the batteries was a distinct step in advance, but slime-treatment apparatus was not in a sufficiently advanced state to meet the requirements of wet crushing in solution, and so it did not take immediate root in this country. We next hear (in 1896) of wet crushing in solution in New Zealand, and later it became the established practice in the Black Hills of South Dakota, from whence it spread over the mining districts of the West. Crushing in the cyanide solution in connection with amalgamation was practiced by the writer on concen-

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trate obtained from roasted sulpho-telluride ores in 1897. Crushing in cyanide solution is, the writer believes, the process of the future, on either raw or roasted ore, and with modern slime-agitation and filtering machinery, leaves little to be desired. In fact, the great advance in fine-crushing appliances during the last few years, coupled with the slime-treatment machinery above referred to, has well nigh rendered the treatment of sand obsolete. It is true that it costs more to grind a given ore to pass a screen of 0.006-in. aperture than to pass 0.02-in. aperture, but the increased extraction usually resulting from the finer comminution of the ore very materially exceeds the cost of grinding, to say nothing of the saving in time and equipment, for at best vats in this cold winter climate are a very expensive installation, particularly when the housing of the vats and the heating of the building is taken into consideration.

A substantial improvement in the process of cyaniding was the patent of MacArthur-Ellis in 1896, for the prevention of sulpho-cyanides passing into solution when treating ores containing sulphides soluble in cyanide solutions. This patent provides for the addition of carbonate, acetate, or sulphate of lead, so that the insoluble lead sulphide is formed in advance, and the working solutions freed from alkaline sulphides.

The decantation process of slime treatment was developed in South Africa, and at present practically all the slime on the Rand is treated by this method, which consists in agitating the slime in weak cyanide solution, usually by means of centrifugal pumps, circulating the sludge from one vat to another, then allowing the slime to settle, decanting the clear solution, adding water, and again agitating and repeating the process till the gold in solution is reduced to the tenor of practical requirements. The decantation process has been gradually developed in South Africa by Butters and others; the process now in use was first successfully applied to the Rand ores by John R. Williams about the year 1896.

One great advantage of the cyanide process over all other practical methods of gold extraction is the fact that it will dissolve gold and silver from raw or unroasted ores. This feature was naturally made the most of in early day advertisements by the MacArthur-Forrest people. It did not, however, apply on sulpho-telluride ores, in the treatment of which roasting became a leading feature; this was first introduced on a commercial sale by the writer at the plant of the Metallic Extraction Co., at Cyanide, near Florence, Colorado, in the treatment of Cripple Creek ores in 1896.

Roasting introduced many difficulties and complications, chief of which were the sulphate salts in poorly roasted ores, but these troubles were gradually overcome, and results have shown that cyanide properly applied is the correct treatment for those ores, because they can be cyanided for about one-half the present cost of chlorinating them and with better extraction. Considerable difficulties were experienced in the early days of cyanidation in securing good precipitation from dilute solutions, until the introduction of the zinc-lead couple by MacArthur, and the zinc-mercury couple by Caldecott, made possible the effective precipitation of the gold from the most dilute solutions.

The introduction of the cyanide process in West Australia to treat sulpho-telluride ores has been fruitful in invention. These ores contain 15 to 20% lime, and early developed the nasty trick of setting in the vats like so much concrete. (I refer, of course, to the roasted ore.) The first apparent success consisted of amalgamating in pans the finely ground ore, then filter-pressing to get rid of the acid salts resulting from bad roasting; next treating the cakes from the filter-press with cyanide solution, and lastly filter-pressing again to drive out the gold-cyanide solution. This process cost about $10 per ton, but is much simplified and now reduced to about $3 per ton.

The process used at Kalgoorlie in its improved form consists of roasting the finely ground ore to break up all sulphates and reach, when possible, a dead roast; next, grinding the roasted ore in pans or tube-mills until 98% of it passes a 200-mesh screen; next, agitating in cyanide solution until the gold is dissolved, and lastly filter-pressing direct from the agitators. This method of treatment is known as the all-sliming cyanide process. The fine-grinding methods of ore-treatment developed in West Australia introduced the filter-press and the tube-mill into the cyanide process. The tube-mill, flint-mill, or pebble-mill, as it is variously called, has been in successful use in the cement business for some time prior to its introduction in practical cyanide work in West Australia. The tube-mill has proved to be the best sliming machine so far discovered, but it is nevertheless pushed hard by grinding pans of the Wheeler type even in the sliming of ores, while the pans excel as fine grinders to, say, approxi-

mately 100-mesh. The filter-press had a short-lived victory, for by the time it was perfected from an ore-treatment point of view, and the costs reduced to something reasonable, the development of the suction-filters showed clearly that the massive cumbersome filter-press, extremely costly to install and expensive to operate, could not successfully compete with the simpler, cheaper, and much more efficient suction-filter, which is now rapidly displacing the filter-press in many of the gold fields of the world.

The Diehl process, also used at Kalgoorlie and, in fact, elaborated for the treatment of those particular ores in the raw state, presents some interesting features, if not new departures, in cyaniding. Owing to the high cost of fuel, labor, and power, roasting on this gold field is very expensive, and while the Diehl process only partially eliminated roasting, yet this method is extremely interesting, showing, as it does, the great possibilities of cyanidation when the ore is reduced to an extremely fine state of division.

In its latest form the Diehl process is found in operation at Kalgoorlie: First, the raw telluride ore is stamped in dilute cyanide solution in batteries, using the ordinary outside and inside amalgamating plates. Second, the crushed ore is passed over concentrating tables and the concentrate resulting from this operation is roasted and amalgamated. The third step is grinding the tailing from the tables in tube-mills to an impalpable powder, practically the entire produce passing a sieve of 200 mesh per linear inch. In the fourth operation the slimed ore is agitated in vats for two hours in a 0.2% cyanide solution; bromo-cyanogen is then added at the rate of 0.04% of the dry tonnage of the charge, and agitation continued for 22 hours. The charge is usually complete in 24 hours' treatment, though it may require a further addition of bromo-cyanogen. The last operation is passing the pulp through filter-presses, the filtrate going to the zinc-precipitation boxes and the residues in the form of cakes, 39½ ins. square and 3 ins. thick, to the waste dumps. The cost of bromo-cyanogen in this process runs from 50c. to $1.50 per ton in ores varying from ½ to 1 oz. gold per ton. The Diehl process is based, first, on the removal of the greater part of the tellurides by concentration and roasting for the liberation of the gold before treating them by amalgamation in cyanide solution; second, sliming the tailing and treating the pulp by agitation in cyanide of potassium solution, to which is added from time to time bromo-cyanogen, which salt will partially attack the tellurides, insoluble in straight cyanide. The success of the process, however, depends chiefly on the thoroughness of the concentration, as high-grade tailing from the concentrating mill invariably means high final tailing after agitation with bromo-cyanogen. The process, in brief, amounts to the removal by concentration of a deleterious material from contact with the cyanide solution, "to be handled by such other methods as the particular circumstances will indicate," as pointed out by the writer in 1894 in an attempt to show the scope of the cyanide process, and that it could "be applied to ores direct, or as a combination process, with amalgamation or concentration, or both, as may be found most convenient for the economic treatment of the ores." The Diehl process has made no progress outside Australia, and even there it is declining. Where roasting charges are high, the process has a fair chance on ores below a valuation of $8 to $12 per ton, depending on local conditions.

Various processes in which the inventors have attempted to precipitate gold from a muddy and foul electrolyte have failed utterly. Hence it has become common knowledge that clear solutions are conditions precedent to successful precipitation from all cyanide solution; and so we come to the last step in cyanidation in which filtration is the dominant note.

Moore obtained an American patent for a suction-filter in 1903, which was introduced at the Mercur Mines (Utah), but on account of defective mechanical contrivances the filters were not quite satisfactory and were subsequently abandoned; in other places, however, the Moore filter has been quite successful. The filter consists of a series of leaves, or rectangular cells with permeable walls, through which the solution is forced, when a vacuum is created in the interior of the cell, leaving the solids (slime) to form cakes on the cell-walls. A number of these cells are bound together in a so-called basket and immersed in a vat of slime until cakes of necessary thickness have formed; then the basket is lifted from the vat and transferred to a wash-water vat and the vacuum maintained in the interior of the cell until the soluble gold has been replaced by wash-water, when the basket is again hoisted, brought over the dumping place and compressed air turned on to displace the cakes. The Moore filter might be briefly described as a movable suction-filter in a fixed vat.

Cassell obtained a patent in 1904 for what might be briefly described as a fixed suction-filter in a fixed vat. In this apparatus the slime and solution are circulated around the fixed filter by means of a centrifugal pump, and when the cakes are finally washed they are displaced by water or air and discharged through the doors provided for the purpose in the bottom of the vats. Both the Moore and the Cassell filters provide vacuum-pipes for lifting the filtered solution from the bottom of the cell to the discharge at the top, but the pressure of 2.5 lbs. per sq. in., necessary for this operation, is not available for filtration in this form of apparatus. A third type, the gravity suction-filter, will soon be on the market, with capacity for making 25 tons and 50 tons of filter-cake at each cycle. This apparatus may be described as fixed filters with a movable vat and gravity flow from the bottom of the filter-cells to the vacuum-pump. When the vat is moved back all the filter-cells are completely exposed, and the cakes can be dumped practically dry. Lastly, we have the Ridgway continuous filter, said to be operating quite successfully in West Australia. In this form of suction-filter a central rotating vertical axle carries arms with depending filters which slowly pass through an annular slime-vat while the cake is being formed, thence through wash-water, and next to the dump, where compressed air is turned on to displace the cakes, thus completing the cycle, and the filter again entering the slime-vat for the commencement of the next cycle. The arms are automatically raised when passing from one division of the annular vat to another, and the valves to the strong and weak solution and of the compressed-air line are automatically operated as the machine revolves.

Returning to the above brief review of the cyanide process, it is quite clear that no chemical improvement of any moment has been made on the process as evolved by MacArthur and Forrest. Weak solution and filiform zinc are everywhere in use today; ores are universally prepared for cyaniding by neutralizing the acidity with lime, while lead salts are invariably used in the cyaniding of heavy sulphides or badly roasted ores. Improvements have been almost entirely along engineering lines, in crushing or pulverizing, in sliming, in agitating, in filter-press work, and in suction-filters; in fact, all along the line of mechanical engineering improvements have been many, and progress steady and continuous.

STRUCTURAL STEEL VS. REINFORCED CONCRETE

By R. E. HAGERTY

CONDENSED FROM "APPLIED SCIENCE," TORONTO

Structural steel was originally necessitated by the introduction of railroads about 1839, and its use has steadily increased since that time. It was first used in small culvert spans as beams, and later was applied to the construction of larger bridges. The continued advancement in the use of steel as an engineering material has been due, primarily, to certain physical properties considerably superior to those of any marketable substance to-day.

1. Of these, the first is unit strength, which is exceedingly high in both tension and compression. Merriman gives the ultimate or maximum strength of structural steel as 60,000 pounds per square inch in both tension and compression. The working stress varies from 12,000 to 22,000.

2. In conjunction with the above comes a property almost equally as great, namely, specific gravity, which is for steel about 7.85, and is remarkably low considering the high strength value.

The above are two of the most influential reasons for the adoption and continued use of steel. They indicate theoretical and practical possibilities.

3. Another property of considerable importance is malleability in mild or structural steel. This condition renders practicable rolling the material into standard shapes, such as

I's, channels, angles, etc., which are so conveniently and extensively used in structural steel methods of construction.

4. A fourth property of steel, which also adds to its feasibility, is the low and almost constant coefficient of expansion. The rate of expansion per degree Fahr., according to Kent, is from .00000648 to .00000686. Consequently, accurate calculations with regard to heat expansion are possible. However, it may be well to point out just here that the rate of expansion for concrete is almost the same.

5. The rigidity of steel, as indicated by its modulus of elasticity equals 29,000,000 lbs. per sq. in., is high and comparatively constant up to the elastic limit, while the modulus for concrete is only about 2,000,000, and is not actually constant, making necessary the use of assumptions which, to a greater or less extent, impair the reliability of theoretical reinforced concrete designs.

A consideration of the foregoing physical properties of steel accounts for the theoretical and practical possibilities incident with the introduction and continued use of the material. However, its practical success has been due to a series of considerations evinced by practice itself.

1. Of these, the one of greatest importance seems to me to have been the capacity for magnitude of structures designed in structural steel. I refer to large bridges, viaducts, skeleton buildings, etc. The most extensive structures in existence are built of this material; but to definitely impress the huge proportions of what has been at least attempted in steel work, kindly permit a few dimensional facts concerning the Quebec Bridge. The structure was of cantilever type, consisting of deck truss approach spans, each 550 ft. long; two cantilever arms, each 562½ ft. long, and one suspended span 675 ft. long, the longest simple truss span ever built. The total central clear span of the bridge from pier to pier was to be 1,800 ft., the longest in the world; while the total length of the bridge was to be 3,220 ft. The depth of the trusses varied from 97 ft. at the portals to 315 ft. over the main piers; and the height of the peaks of the main post above the river was 400 ft. The clear headway over the high tide was 150 ft., and it was proposed that the new bridge have a clear span of 200 ft., in order to permit vessels of the "Mauretania" type to reach Montreal. Magnitude, then, is an important capability possessed by structural steel, which may never be approached by reinforced concrete.

2. In close connection with magnitude comes the possibility for accurate, delicate and complicated design and construction, certainly not attained in any other building commodity yet invented.

3. Inspection is a potent factor in the safety of structures. Thoroughness in this respect is facilitated to a high degree in the methods employed in steel construction. A large portion of the work is done in the shop of the bridge company who may be the contractors for a certain piece of steel work. Large members are fabricated in the shop and shipped as unit pieces to the place of erection. Individual members weighing as much as 100 tons were used on the Quebec Bridge. It may be easily understood, then, that shop inspection is considerably superior to field inspection, which predominates in reinforced concrete construction. Hence, the inspection of structural steel is decidedly more reliable than is that of the other system.

4. The same condition that increases the efficiency of steel inspection also necessitates the probability of first class workmanship. Judging even superficially from the nature of shop work its superiority over field work is evident. The systematic concentration of the designing office, the drawing office, the template shop, and the various accessories of the structural workshop, such as electric cranes, pneumatic hoists, high pressure punching and riveting machines, is bound to induce good workmanship as opposed to the rough-and-ready temporary methods prevailing in the field. This apparency is verified by experience. Years of observation of the manufacture of steel also has its effect on good workmanship.

The prominence of this argument in favor of steel is also well shown by the Quebec Bridge disaster. A professional man viewing the tangled mass of steel which overhangs the south main pier cannot but observe the excellent character of the workmanship which must have been placed in the material for that bridge. The steel overlying that pier fell with a tremendous momentum a distance of nearly 400 ft., and still there was but little rupture of material or dissembling of parts.

This is, indeed, a wonderful tribute to a condition of almost perfect workmanship which has been attained in structural steel practice.

5. The problem of erection is much simplified by methods of steel work. Members are assembled and erected by derrick or traveller,

and are fitted into place with ease and accuracy, and are then bolted or riveted. Hence, ease of erection is another very strong point in favor of structural steel.

From the reasons set forth in the foregoing the extreme and indispensable value of steel in engineering construction is apparent.

Nevertheless we have still to deal with the financial question. With the invention of the Bessemer process the cost of mild steel as used in large quantities was reduced 75% or more, making the material financially possible. Further, with the closing years of the nineteenth century came a demand for steel which fully doubled the market for this commodity. Conditions imposed on owners of property lying within the business districts of large cities are responsible for the adoption of what is termed the high building. Centralization of business promoted a high increase in land values around these centers, such as the "Heart of Chicago." Consequently a demand for paying investments, and, therefore, for more floor space, led to the erection of the high building, when "skeleton" construction came into vogue. The extensive space occupied by the solid masonry construction was greatly decreased by the structural steel column, and on this account steel became a great financial success.

REINFORCED CONCRETE.

The durations of existence of structural steel and reinforced concrete are roughly in the proportion of a century to a decade, and all fair considerations of the possibilities of the latter material must take this into account. The process of establishing reinforced concrete has been similar in its stages to that of steel, but the discussion will be somewhat different. Steel has been established by a series of favorable points as mentioned before, and its progress has been repelled by one or two large properties of doubtful economy, fireproofness and durability. These have led to the spontaneous establishment of the newer material, which in reverse, strangely enough, has to battle with the less important, but more numerous considerations which built up structural steel.

Considerable theory has been developed concerning reinforced concrete, such as the formulas of Talbot, Hatt, Thacher and others. These calculations are based on the special ability of concrete to withstand compression, necessitating the use of only a small amount of steel placed in such a way as to assist the concrete in tension. The theory assumes a condition of no slipping of the embedded metal in addition to some assumptions common to both systems of design. The general reliability of concrete as a material is not as good as that of steel, and hence design is affected as regards pure theory. We may say, however, that theoretically reinforced concrete is a success.

With regard to strength representative tests have served to convince even the most conservative that reinforced concrete has beyond doubt the ability to carry load. These experimental tests are substantiated by practical results such as large structures which are actually standing. It is evident then that reinforced concrete is a theoretical and practical possibility.

POINTS IN FAVOR OF REINFORCED CONCRETE.

1. Probably the most erroneous conception ever acquired by the public was that of the fireproofness of structural steel. Columns of steel in buildings will frequently buckle from excessive heat fifteen minutes after the outbreak of a fire, showing their incapability to withstand the flame successfully.

It has been stated that large timber columns of the "slow burning" form of construction are more fireproof than steel. However, to offset this, various forms of fireproof protection for steel have been used. Of these solid porous terra cotta or hollow terra cotta tiles have been extensively applied, but as yet these methods have not proved successful.

Reinforced concrete square columns are not seriously affected, for more than ¼ in. from surface or for more than three inches radially at the corners. It is indeed generally conceded that concrete is the only decidedly fireproof material known which is capable of application to engineering purposes. This argument is worth a host of others, and cannot receive too much attention.

2. The durability of concrete and its importance as an argument can also hardly be underestimated. It ranks, I believe, equally with that of fireproofness, and the tests are even more convincing. In Rome can be found to-day a number of examples of concrete constructed over 2,000 years ago. The concrete of the Pantheon dome, the House of Vestals, the Aqueduct of Venus still remains, while stone in ancient ruins has long since crumbled away.

The corrosion of steel is well known. Difficulty has been found in obtaining suitable

paint even to minimize the powerful oxidizing effect of air on iron surface. However, it is now a well-established fact that steel embedded in concrete is rendered absolutely rust proof. Some writers even maintain that a coating of rust in the steel before placing in the concrete is beneficial. But in any case we may say that durability of concrete reinforced is strangely enough two-fold. Both phases, viz., the durability of the concrete itself and that of the embedded steel, are established by an exhaustive set of tests recently completed by Professor Norton, of the Massachusetts Institute of Technology. The only condition the Professor specifies is to "mix wet and mix well." I might add that "the durability of iron embedded in concrete is attested by iron clamps found in the mortar joints in the Pantheon after a period of fully 2,000 years, which were in good condition."

The ultra-importance of these two arguments is evident. However, there are some others worthy of mention.

3. In direct connection with the above comes the argument which is advanced with impunity by all advocates of reinforced concrete. That is the low cost of maintenance which is practically nil, while the painting of steel and the higher insurance rate on steel structures increases the cost of maintenance of buildings, etc., of this type.

4. The monolithic nature of reinforced concrete design is clearly shown to substantially increase efficiency in resisting vibrations such as are caused by machinery or the shock from earthquakes, etc.

Experiments to determine the results of shocks on various floor systems have been carried on recently by the Paris and Orleans Railway Co. Floors of the steel beam and brick arch construction, and of the reinforced concrete system were constructed, using the same live load in the design for both. In proportion to the impacts, the vibrations of the steel beams and brick arch construction to the concrete construction were 20 to 1 in amount and 11 to 1 in time of duration.

5. From the contractors' standpoint, steel for reinforcing can be supplied within a few weeks' notice instead of so many months as is generally the case with structural steel orders.

6. Noiseless construction is often a matter of practical and commercial consideration. The construction of the Marlborough Blenheim Hotel, Atlantic City, was carried on while guests remained in the older portions of the building. The hotel profits would undoubtedly have been impaired by the noisy riveting of the structural steel erection.

7. Concrete when erected is claimed to be sound-proof.

The above are a few of the many points advanced in favor of reinforced concrete. In the main, I believe I have shown that this commodity, when fabricated, is decidedly an engineering success. However, unlike steel, most of the disadvantages lie with the construction.

DISADVANTAGES OF REINFORCED CONCRETE.

1. Workmanship.—The greater portion of the construction of reinforced concrete is done in the field. Consequently the tendency is naturally toward less efficient workmanship. On this account the work itself is less reliable, also, owing to the difficulties met with in "form building," exact and truly finished workmanship is difficult and unusual.

2. The contractor is subject to varying local labor conditions, to a large extent. The cost of transporting workmen to various "jobs," which are frequently scattered, is a consideration of important practical bearing.

3. From the nature of the construction, difficult delay and mistakes in placing the steel reinforcement are evidently liable. Hence the chance for properly executed design is materially lessened.

4. The large amount of lumber used during construction greatly increases the possibility of fire. This is especially objectionable in the hearts of cities.

5. One of the greatest engineering objections is the difficulty of reliable inspection. Much has been said with regard to this phase of the subject, and it will merely be necessary to refer to it as being one of the most flagrant complaints against reinforced concrete. The difficulties of obtaining reliable inspection may be classed perhaps, as follows:

(a) Non-uniform testing of cement.

(b) Incompleteness of inspecting the mixing.

(c) Difficulties in placing, etc.

6. Every portion of construction has to be molded, too, exactly in its permanent position. Hence the term "clumsy" construction has been applied. The method of raising the concrete members has been tried, but is impractical on account of the excessive weight of the concrete.

We have remaining the discussion of the large question of financial possibility of rein-

forced concrete. The cost is largely increased, of course, by these constructional conditions. For instance, the cost of placing reinforcement is about $12 per ton of steel. But the all-important item is the cost of "forms." This I believe, will average over 30% of the total cost of the concrete in a structure. Certain advocates of reinforced concrete claim that its cost is 25 per cent. less than that of steel. I have in mind a building erected according to the reinforced system, and the contractor lost several thousand dollars by underbidding structural steel. Personally, I believe that the average cost of reinforced concrete is usually a little in advance of steel. Whether or not this extra financial outlay is warranted is entirely a matter of opinion, yet to be shown by the results of more extensive experience.

ADAPTABILITY OF REINFORCED CONCRETE.

Justification for cost is an important consideration, and may be better discussed by a brief reference to some specific examples.

1. The fireproof argument hardly applies to bridges. However, durability and resistance to vibration are eminently required, and are attained by the use of reinforced concrete. But "centering" is usually difficult, expensive, and sometimes impossible. Self-support during erection is not feasible, and long span bridges are unusual.

2. Reinforced concrete is extremely well adapted to viaducts, which must resist vibration, be fireproof, and durable. The formwork is comparatively simple and uniform, and therefore inexpensive. The size of columns in the substructure is immaterial, also construction is easy since it is mostly executed near the ground in continuous viaducts. Of course the nearer a viaduct tends to become an ordinary bridge, the less do these favorable conditions apply. The above remarks apply more especially to the beam type of viaduct.

3. Experience has shown reinforced concrete, for the most part, to be well adapted to culvert construction.

4. It is well adapted to conduit pipes. The form work is somewhat difficult but is uniform.

5. For dams reinforced concrete may be well used, since durability is here of so great importance.

6. The factory building is one of the very best applications of reinforced concrete on account of the resistance to the vibration of machinery. The size of the columns here is of no especial importance, since factories may be built in the outlying districts where land space is of little account, also beauty of construction is not expected in factory buildings.

7. Curtain walls of reinforced concrete are objectionable on account of permeating dampness. This may be partially overcome by the Sylvester process which consists of a coating of soap and alum solution.

8. Probably the best application of reinforced concrete is in floor construction, especially for factory buildings or warehouses on account of minimum vibration and great strength.

9. Finally, office buildings; these must be fireproof, hence the demand for reinforced concrete, but here the financial question is monumental. In the first place the cost of construction is of doubtful economy. Secondly the size of the columns necessitated by reinforced concrete brings us back to the original condition which led to the adoption of structural steel in high buildings, viz., the saving of floor space.

It will be clear from the foregoing, I think, that very high buildings must needs be essentially of structural steel. However, with the development of the esthetical capabilities of reinforced concrete it is quite within the range of practicability that buildings up to 8 or 10 stories should be erected entirely of reinforced concrete. In this connection the recent invention of a snow-white Portland cement will be significant.

In the discussion of these few remarks concerning two subjects which have in justice proved to be of live issue among engineers, I have endeavored to maintain absolute impartiality, as previously stated. I would urge you gentlemen to consider the advisability of acquiring this attitude in all references to the comparative merits of structural steel and reinforced concrete. There is, of course, an infinite amount to be said on this vast subject, but I beg leave to conclude my limited remarks with a brief recapitulation of the points set forth.

The introduction of steel was a matter of slow but steady progress throughout nearly the entire nineteenth century. The extreme physical fitness combined with large constructive possibilities and above all the financial success of the material gradually established, a foothold that will probably never be shaken. But the greatest victory was attained by the tremendous tide of popular opinion which staked life and reputation on the supposedly

fire resisting qualities of structural steel. This, combined with the other reasons, of course, raised the use of steel to an altitude only measured by the tallest skyscraper in New York City. As previously shown, the fallacy of this same idea was the opening flaw which permitted of the inauguration of the newer material, reinforced concrete; and this commodity strangely enough eminently met the requirements lacking in steel.

Just here, however, it is of keen interest to note that the arguments advanced are reciprocally opposite in the cases of the two respective materials to which feature allusion has already been made. The "fireproofness" and durability of concrete in opposition to structural steel is evinced by the liberality of the use of reinforced concrete in the rebuilding of San Francisco, while again, the constructional features are exceedingly poor, as opposed to the marked appropriateness of steel work in this connection. We have then a sort of equilibrium of forces acting for and against the two commodities. In brief, the only deficiencies of steel are overcome by concrete, and vice versa.

We can all agree, I think, that the points of each material are such that neither arguments may be overlooked. In short, there is a very great deal to be said on both sides. It has seemed to me exceedingly regrettable that there exists at present such intense warfare between the devotees of these two engineering commodities. The fight for reinforced concrete has been brilliant, bitter and aggressive, and to-day it remains on the engineering market a commodity of undisputed reputation, owing to certain abstract qualities such as "fireproofness" and durability, and in spite of certain drawbacks which tend to render it unpractical. For instance, very high buildings and large bridges can never be other than essentially structural steel.

On this account I believe that the regrettable warfare will result in a very happy combination of both reinforced concrete and pure structural steel. The dawn of this era seems to be at hand in the new McGraw building of New York. Here the columns consist of laced angles with concrete applied principally as a protective attribute. In this, I think we have the nucleus of a system of construction which will be as near as possible to absolute perfection in spite of the increased original cost, which by the way, would in the end prove the cheapest. In this connection, floors, beams, and perhaps curtain walls might well be pure reinforced concrete, while roof-trusses, etc., had better remain of structural steel. This combination system, it appears to me will eventually become universal, and might justly be called "Steel-Concrete System" of construction as a combination of the two systems now distinctly separate.

WOOD DISTILLATION*

By W. C. GEER

There are two distinct processes for obtaining valuable products from wood by distillation—destructive distillation and steam distillation. In the destructive process the wood fibre is broken down and new compounds are formed, but in the steam process this is not properly the case. In both processes the volatile compounds of the wood are vaporized.

In destructive distillation heat is applied below the wood-containing vessel, which has a comparatively small pipe as its only outlet. The heat vaporizes the volatile compounds, such as water and turpentine, and breaks down the non-volatile compounds, such as cellulose and the wood gums; it forms a number of new compounds, usually of a simpler chemical nature, and these in turn are vaporized with the water and turpentine, leaving a residue of charcoal. The decomposition of the wood in this process is exceedingly complicated and is not yet fully understood.

In steam distillation, which is much simpler, the wood is chipped and placed in a closed receptacle into which steam is blown from a boiler, and the volatile compounds which are not chemically united with the rest are vaporized and carried out of the retort with the steam. Though in practice the wood is often so much overheated that the wood fibre is slightly decomposed, and though it is quite

*From Forest Service Circular 114, U. S. Dept. of Agriculture.

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possible to carry the overheating so far that the process becomes one of destructive distillation, it is nevertheless true that "steam distillation," as the term is technically used, signifies the separation of volatile products from wood with, at most, but little decomposition of the wood fibre.

With both these processes the vaporized compounds, after leaving the retort, pass through water-cooled tubes, where they are condensed into the crude liquors, which, after refining, yield marketable products.

Different woods give different marketable products after distillation. Thus, the hardwoods—beech, birch and maple—yield acetate of lime, wood alcohol and charcoal, and longleaf pine yields turpentine, tar, pine oils and charcoal. This difference in the products is due to the fact that pine woods are resinous, while hardwoods are non-resinous. From the point of view of products, therefore, it is necessary to distinguish between the kinds of wood used, as well as between the distillation processes.

DESTRUCTIVE DISTILLATION OF HARDWOOD.

Hardwood distillation has been an established industry in the United States for a number of years. The products already mentioned are wood alcohol, charcoal and acetate of lime, each of which has important uses. The plants are located in the northern part of the United States, where, except for the Appalachian hardwood belt, the hardwoods are most common.

The woods used are largely beech, birch and maple, with the last preferred. The wood is cut into cordwood lengths and allowed to season for a year. According to the best information, the amount of the products obtained from green wood and from ordinary dry wood is not different, cord for cord, but the higher water content of green wood dilutes the distillate and necessitates more fuel for the carbonization. Excessive seasoning will doubtless reduce the yield of valuable constituents. Body wood is better than slab wood. Very small wood, such as thin edgings, carbonizes so rapidly that it must be mixed with larger pieces. The problem of the destructive distillation of sawdust has not yet been satisfactorily solved.

Apparatus.—Wood is heated or carbonized in three forms of apparatus: (a) In brick kilns, (b) in retorts, (c) in ovens.

The charring of wood is a process as old as civilization. In the early days the wood was charred under sod in the old charcoal kiln, which has been a familiar sight over a good part of the world. The modern charcoal kiln is so made that valuable vapors are condensed from the smoke, which in the old-fashioned kiln escaped into the air and were wasted. Kilns are now mainly used to produce charcoal for blast furnaces for pig iron. They are made of brick, with a circular base, and divided approximately into two semicircular sections. They hold each about 50 cords, and are charged and discharged by hand. The vapors are carried off into condensers, where the condensible ones are liquefied.

The name "retort" is given to a small form of cylindrical vessel, holding about three-fourths of a cord. The retorts are set horizontally in brickwork, in pairs, each pair forming a "battery," and heated from beneath. They are filled and discharged from a single door in front, which can be tightly fastened. The top of the battery is often tiled and serves as a drying floor for acetate of lime. The condensers are of copper, and are cooled by water. A "run," from charging to recharging, takes twenty-four hours.

The invention of the "oven" form of carbonizing vessel marked a distinct forward step in wood distillation. Oven kilns are made large enough to hold from two to four cars, which are run in on tracks, each loaded with about 2 cords of wood. They are usually fired separately, and the vapors pass over into the condensers, either at the side or at the end. In other respects they resemble the "retorts."

Products.—Four crude products are obtained from each of these forms of carbonizing closed in large coolers, which are similar in vessel; (2) a non-condensible gas, which is carried off by suitable pipes; (3) an aqueous liquor known as "pyroligneous acid"; and (4) wood tar, which is condensed with the pyroligneous acid.

The charcoal is cooled differently in the case of each distilling vessel, though in all cases it is cooled for forty-eight hours. With kilns, it is allowed to cool before being removed; with the retorts, it is shoveled into drums or cans and sealed from the air; and with the ovens, the loaded cars are run out and closed in large coolers, which are similar in form to the ovens.

The gas from the kilns is piped back into the kiln furnaces, where it serves to carbonize the wood. The gas from retorts and ovens

is burned under the boilers or under the retorts.

The pyroligneous acid and the tar run off together from the condensers into vats, where the tar settles. The pyroligneous acid is reddish-brown in color and has a strong, characteristic burnt-wood odor. The tar, when in thin layers, is dark brown in color, and has a bad odor. These two liquid products are refined by processes which in general are the same for each of the three forms of carbonizing apparatus. The processes differ somewhat, however, at the different plants.

Dissolved in the tar are some of the valuable compounds of the pyroligneous acid, while dissolved in the pyroligneous acid are some tarry bodes. Both liquids are distilled in order to concentrate the valuable substances, which are chiefly acetic acid and methyl, or wood, alcohol. The concentrated liquid containing the acetic acid and methyl alcohol is neutralized with lime and distilled from a "lime-lee" still, giving, (1) a residue which, upon evaporation, yields gray acetate of lime, and (2) a distillate which, upon refining, yields the various grades of wood alcohol.

Some plants obtain a crude, brown, evil-smelling wood alcohol, of 82% strength, which is sent to a refinery for further treatment; others obtain a 95 to 99% product without color or unpleasant odor. Wood alcohol is ill-smelling only when impure as a result of incomplete refining.

Oven and retort plants which produce alcohol no purer than 82% secure about the following average yields from wood distillation per cord of wood:

Charcoal .....45 to 52 bu.
Gray acetate of lime.....180 to 225 lbs.
Wood alcohol, 82%.....8 to 10 gals.

The lack of chemical supervision at the works makes statements of yield a little confusing, since wood alcohol and acetate of lime are variable in quality, and the number of gallons and pounds may therefore actually represent products of quite different composition.

Kiln plants obtain about the following yield per cord of wood:

Charcoal .....45 to 52 bu.
Acetate of lime .....90 to 150 lbs.
Wood alcohol, 82%.....4 to 6 gals.

Use of Products.—These compounds have a variety of uses, which may be briefly mentioned. Charcoal is used in blast furnaces for the production of pig iron, in copper and sugar refineries, in the production of gunpowder, for fuel, etc. Wood alcohol is sold under a variety of trade names, such as "columbian spirit" and "colonial spirit." It is most widely used as a solvent in the production of shellacs and varnishes. It is also used in hatmaking, in perfumery, in the coal-tar dye industry, in manufacture of formaldehyde, and for mixing with grain alcohol to produce "denatured" or "industrial" alcohol. The acetate of lime is a gray, finely crystalline body, which is used in the manufacture of wood vinegar, acetic acid, many commercial acetates, acetic ether, acetone and other products. (From the acetone may be produced iodoform and chloroform.)

A number of receipts for the preparation of denatured alcohol have been recently authorized by Congress and established by the Commissioner of Internal Revenue, so that denatured alcohol, with its due admixture of wood alcohol, is now a market article. The wood distillation plants now in existence in the United States are able to produce probably 30,000,000 gals. of wood alcohol annually.

Denatured alcohol is now a competitor of wood alcohol. At present the producers and refiners of wood alcohol are in suspense as regards the extent of the consumption of the product for denaturing purposes.

STEAM DISTILLATION OF HARDWOOD.

Several species of hardwood are distilled by steam in order to obtain valuable essential oils. Sweet birch, for example, yields "oil of wintergreen," an oil used in medicinal preparations. No thorough study has yet been made of this division of the subject, but it is known that a small industry is supported.

DESTRUCTIVE DISTILLATION OF YELLOW PINE.

The destructive distillation of yellow pine is carried on in the Southern States, where the distillation plants are so widely scattered that a statement of the location by States would mean but little.

The wood generally used is that of longleaf pine, from which turpentine and rosin are mainly obtained. At some plants, however, longleaf pine, shortleaf pine, Cuban pine and others are indiscriminately used, but for the best results longleaf and Cuban pines are selected. The most valuable material is wood rich in resinous contents, or "fat," in which lightwood and stumps rank first, wood immediately under the "box faces" next, and slabs and other mill refuse last. Pine sawdust is not used for destructive distillation.

Apparatus.—Iron or steel retorts are used, varying in capacity from 1 to 4 cords. They are either vertical or horizontal. The vertical retorts have their long axis upright, and are set singly in brickwork with suitable flues, usually with the openings for charging and discharging at the top and bottom. The fire-box below is at one side, so that the heat goes around the outside of the retort itself. Few of these retorts are now in use.

The horizontal retorts are similar to those used in hardwood distillation. Though they differ as to form, all are cylindrical steel vessels set in batteries in brickwork, and are charged and discharged through doors at one or both ends. The gases escape through pipes to copper condensers. The fire-box is sometimes constructed to fire two retorts at a time, though usually but one.

Products.—Though there are a number of methods which differ somewhat in results, the five products usually obtained are: (1) Charcoal; (2) a non-condensible gas; (3) light oils, which are often taken in two fractions, one of which is a crude turpentine; (4) tar, and (5) pyroligneous acid. At some plants the light oil vapor, which volatilizes easily, is led off into condensers with the gas and pyroligneous acid, while the tar, which is heavier, is drawn off at the bottom; at others, the entire volatile product is driven off through a pipe at the top, and, after passing through the condenser, is separated into the crude turpentine and tar fractions.

There is no more uniformity in heating methods than in the form of the retorts. The run is thirty-six or forty-eight hours, or longer.

Charcoal which is to be sold is cooled in the retort, and that which is to be used for fuel is drawn hot and sprayed with water to prevent fire. The gas is allowed to run to waste or is burned under the retorts and boilers.

The pyroligneous acid from hardwoods contains the most valuable products, but that from pine, which has a strong odor and a reddish-brown color, is of such different composition that very little is done with it. The yield from a cord of pine wood is, according to the most widely accepted figures, not more than 3 gals. of 82% wood alcohol and about 70 lbs. of brown acetate of lime. The extraction of wood alcohol from pine wood is not at present on a commercial basis, and at the majority of plants the pyroligneous acid runs to waste.

The crude turpentine is a dark red oil with the bad odor associated with products of destructive distillation. After proper fractional distillation, it yields for market a nearly colorless turpentine which has a distinctive odor.

The tar is sometimes refined far enough to produce a good quality of retort tar and to yield oils which, with the heavy distillates from the crude turpentine, make disinfectants, wood creosote, and a number of market articles.

The refining processes, which are largely secret, are not the same at all plants, while the products sold are far from uniform.

Since few plants operate under the same conditions, and since a number of products may be obtained from the tar and crude turpentine, it is difficult to estimate the amount of products obtained from yellow pine. Moreover, the wood itself varies widely in resinous content. Heavy, rich "lightwood" contains the largest quantities of turpentine and other oils, whereas other kinds of "lightwood" may yield but little. Sapwood yields the least. The following table shows as nearly as practicable the ordinary yields per cord of wood obtained in practice by the destructive process:

Refined turpentine	7 to 12 gals.
Total oils, including tar	50 to 75 gals.
Tar	40 to 60 gals.
Charcoal	25 to 35 bu.

Uses of Products.—The turpentine is used as a second grade, inferior to gum turpentine. There are no recognized grades of destructively distilled turpentine and the composition of the turpentine from different plants is not uniform. Formerly it was poorly refined; it is now made practically colorless. In the refining, certain heavy oils are obtained, which, when combined with similar heavy oils from the tar, are made into "pine oils," used as disinfectants, paint dryers, wood preservatives, etc. One of the uses for the tar is cable coating. The uses of the acetate of lime, in this case "brown acetate," have already been mentioned. The charcoal is burned at the plant or sold for fuel. The pyroligneous acid in its crude form is occasionally sold, although most of it goes to waste.

Several causes have led to many failures among plants of this kind. One of these was bad management. Men engaged in the business, without training or a knowledge of the market, expected an immediate demand for the products. Another cause was the use of inferior retorts, which in many cases were made of thin steel and so were quickly burned out. A third was lack of perseverance when difficulties arose.

STEAM DISTILLATION OF YELLOW PINE.

The plants which distil wood by the steam method are located in the yellow pine belt. In general, the wood is the same as that used for the destructive distillation of yellow pine, but is separated into classes. Steam plants use the richest wood that can be secured, since turpentine is the only valuable product, although the wood after extraction is used for fuel. The wood is divided into three classes: (1) The rich "lightwood," of which several grades are used; (2) stumps, which are also rich in turpentine; and (3) sawmill waste, which includes sawdust, butt cuts, and slabs. All wood must be "hogged" into chips before it is placed in the retorts.

Apparatus.—Both vertical and horizontal retorts are successfully used. But the wood is treated by two different methods, one using superheated steam under low pressure and the other saturated steam under higher pressure.

With superheated steam a vertical retort is used, and the steam, before entering the retort, passes through a superheater, which raises its temperature high enough to readily volatilize the turpentine. From the condensers the distillates run into a separator.

For saturated steam several sorts of retorts are used, and the steam enters them directly from the boiler. There are a number of patented devices, the most important differences in which have to do with methods of charging and discharging. The fundamental idea, however, is to maintain a sufficient pressure of steam, throughout the run, to facilitate rapid extractions. A separator is used, as with superheated steam.

Products.—The products of both processes are crude turpentine and water, in a separator tank, and chips left in the retort. The turpentine, which is lighter than water, floats on the surface and is easily drawn off, ready for refining. The chips, after drying a short time in the air, are suitable for fuel.

In order to obtain a market grade of turpentine, the crude product should be refined by distillation with steam in a copper still. As it comes from the retort its color is slightly yellow.

There is the same variety in methods used as in other kinds of wood distillation, and consequently the same lack of uniformity in the products. Much remains to be learned as to the best method of refining turpentine so as regularly to secure the best grades.

The amount of turpentine obtained from steam distillation varies widely. The wood itself varies greatly in richness. A conservative average per cord is given in the following table (the difference between stumps and "lightwood" is slight enough to be disregarded):

Lightwood:	
Refined turpentine.....	10 to 15 gals.
Heavy oils.....	1 to 3 gals.
Sawdust:	
Refined turpentine.....	2 to 4 gals.
Heavy oils.....	½ gal.

The refined turpentine is of reasonably uniform quality, is nearly colorless, has an agreeable odor, and has a fair market at a price somewhat below the market price for gum spirits of turpentine.

COMPARISON OF METHODS.

Comparing the steam methods with the destructive methods, although there is room for difference of opinion, it would seem that the steam distillation is open to the wider development. The successful destructive distillation plants are those which are run by men who have remained in business long enough to establish their processes and methods and the markets for their products. Turpentine, the leading product, is probably produced less expensively by the steam method, and the steam apparatus necessary to handle a given quantity of wood per day, say 50 cords, is easier to operate.

There have been fewer failures in steam distillation than in destructive distillation, perhaps because it is of more recent development, and because those promoting the enterprises have been able to profit by the mistakes of their predecessors. Yet many operators have failed, mainly because they had not familiarized themselves with the fundamental principles controlling the successful construction and operation of a plant.

The figures given above are not intended to compare yields by destructive and steam distillation from the same grade of wood, but simply the yields obtained by the two methods under actual conditions, where, in point of fact, very different grades of wood are used.

There is but scanty published information on the properties of the turpentines produced by these two processes in America, or on their actual value in the paint and varnish business. Up to the present these turpentines are merely competitors of "gum spirits."

THE PROTECTION OF BUILDINGS FROM LIGHTNING*

By ALFRED HANDS, F. R. Met. S.

The Science of Lightning Protection.—The science of protection from lightning is not an easy one, but why is it difficult? We know that, in accordance with electrical law, a discharge will take the path of low resistance in preference to that with a high one. If we took a piece of stone and placed a line of metal along it from end to end, except for a break in the center, and then subjected it to a discharge from an electrical machine; or, if we had a real obelisk composed only of the same material, and fitted it with metal in the same way, and it was struck by lightning, the spark would pass along the metal. If damage occurred it would only be at the gap; the discharge would not go through the masonry in preference to the metal. The experiment might be repeated any number of times, either with the model in the laboratory or with a real obelisk and nature, and the result would be the same.

If we completed the line of metal so as to form a continuous conductor, the obelisk would be protected. Electrically bad joints and a bad earth connection would not force the discharge to go through the masonry. Bad joints would only cause injury to the conductor, and a bad "earth" would probably result in a barrow load or so of soil being blown up. The concussion due to the explosive force that blew up the ground might possibly crack the masonry slightly on the surface, but this would be the worst that would happen. But if the obelisk, in place of being solid masonry, was built hollow, with stone steps in the interior, and with a gas-pipe carried up inside to afford light at intervals, the problem would be an entirely different one. There would be a rival conductor in the interior—an alternative path of metal—with a perfect earth connection, because the ramifications of the gas-main underground would afford only a nominal resistance to earth. Therefore, if the intended conductor had a high resistance, the bulk of the discharge would spark through the wall and pass to earth by the gas system. The earth resistance of a gas-main is a mere fraction of an ohm, and it is practically impossible to get an appreciably lower one for the conductor; so, even if we gave the latter what is called a "good earth," there would still be the rival in the interior and the danger of division of the discharge between the two paths of metal, for a thickness of a foot or two of masonry is poor insulation to withstand the voltage of a lightning flash. For efficiency it would not only be necessary to have a conductor with a minimum resistance, but it should be fixed on the opposite side of the structure to the gas-pipe, so that there would be a sufficiently thick buffer of insulating material between them and the discharge would not be able to spark through. I consider the safe distance for masonry or brickwork to be a little over 4 ft.; less than this is risky, because the question of sparking through the wall would depend on the relative thickness of the masonry and the power of the flash.

The obelisk is the simplest possible case. If all buildings were as simple as this, protection from lightning would be so ridiculously easy that a council schoolboy could, by means of a few set rules, learn to protect them efficiently. The problem one is sometimes confronted with is more like this; metal cowls on chimneys; lead-covered ridges and flashings; metal girders, stoves, and casements; rain-water gutters and pipes, gas and water service pipes, etc.—altogether affording a problem that would require very careful studying.

A very common case is that of a short elevation rod fixed on a chimney, and near it a much higher mass of metal in the form of a cowl. The discharge passed through the cowl, and shattered the corner of the stack in passing to the conductor. Here the elevation rod should be fixed on the cowl, or else a connection of metal should be made from the cowl to the conductor.

Some Results Due to the Surging Effect of a Discharge.—Electricity—or, perhaps, I should say, the movement in the ether that causes

*From a lecture delivered at the School of Military Engineering, Chatham.

electrical effects—has properties that correspond to inertia and momentum in matter and in scientific terms they are called electromagnetic inertia and electrokinetic momentum. We have to remember that when a conducting system receives a discharge, it is momentarily charged because of inertia having to be overcome, and the consequent sudden rise and fall of potential does not leave outlying parts of the system at a normal level. There is an alternate rise and fall like the water in a bath that has been tipped up suddenly at one end. Although the effect is all over in a fraction of a second, damage might occur which, although slight in itself, might have serious results, so precautions should be taken to guard against it. Although water is not a good analogy, it is the best I can think of to bring the action to mind. Imagine a system of canals. Suppose a main canal, open to the sea, and equivalent to a conductor with a good earth connection. To right and left suppose two branch canals, equal to branch lines of metal from the conductor, the former having only a very weak wall dividing it from a pool of water, while all the other banks are sufficiently high and strong to resist pressure due to the rise and fall of the water-level. The pool represents a piece of metal near the far end of the branch conductor and not connected to it. If the level of the water in the main canal were suddenly raised enormously, there would be a rush along the canal due to the passage of the extra head of water to the sea, but the water in the branch canals would not remain at normal sea-level; there would be a surging effect along them. In the left-hand canal there would be no effect beyond the rise and fall of water; but with the right-hand one, the dividing wall, being very weak, might be broken down. The strength of the wall represents the insulating strength—or, in other words, the distance—between the branch conductor and the adjacent metal, and would determine whether a breakdown, or spark, occurred between the two.

We next come to effects that are by no means uncommon, but have hitherto been misrepresented owing to their not having been understood; cases in which objects are struck by lightning and effects occur at some distance away. For instance, a church spire might be struck, with or without a conductor upon it, and persons in a neighboring house, who happened to have metals in their hands at the time, might receive slight shocks that would, perhaps, appear severe because they were unexpected. A man walking with a gun on his shoulder near a tree when it was struck would get a shock, and say he had been struck, too. Workmen handling metal tools are especially liable to these effects when near lightning-struck spots. I regard these effects due to a surging or wave effect, somewhat similar to what I have been describing, but with the earth as the conductor between in place of a line of metal. It is often thought that when a lightning flash reaches the earth—to put it in popular language—the effect is all over; but we must bear in mind that generally before a discharge occurs the potential of a locality is raised—or lowered as the case may be—enormously, and this altered potential does not necessarily return to the normal again without effect. Taking a water analogy again, I would liken it to a waterspout forming on the surface of a lake and then suddenly collapsing. The effect would not be over the moment the column of water struck the surface, there would be a surging or wave effect that might loosen the banks at some distance away where they happened to be weak. So with a lightning discharge we may imagine the sudden rise and fall of potential as setting electrical waves flying through the earth; where metals were so placed as to give rise to a difference of potential of sufficient magnitude, there the effects would be felt as shocks by persons in the position of links between those metals and the earth, or the effects would appear as sparks where two metals were so placed as to be just in the right way to catch these waves. This is how the matter presents itself to my mind, and I have found it explain many incidents that had appeared mysterious and that could have been foreseen under this aspect of the matter, and, it appears to me, under this aspect only. The greatest distance to which I have so far been able to trace effects of this kind has been about half a mile, but possibly, if the discharge were exceptionally severe or the conditions unusually favorable, effects might be traced even further.

I was at Heathfield Station, in Sussex, one day, when I noticed marks of burning and a combination of metals that led me to think I had accidentally come across an interesting case, and, having time to spare, I examined the buildings carefully. The railway line here is in a cutting, over which there is a road bridge. Above the platform on one side of the station is the booking office, abutting on to and level with the road. From one end of the booking office a foot bridge, roofed with corru-

gated iron, leads across the line to give access to the other platform. From a gas-main along the road a pipe runs into the foot bridge just outside the booking office, and rises up to a gas jet not far below the roof of the foot bridge. Some telegraph wires terminate in shackles on the wall of the booking office above the foot bridge, and from these shackles insulated wires were carried into the booking office, passing on their way down the roof of the foot bridge and within about an inch of the gas-pipe, thus forming a connecting link between the iron pipe and the iron roof. The rubber covering of these wires had been ignited just by the gas-pipe, and the small fire occasioned had scorched some adjoining woodwork. I came to the conclusion that lightning had not struck the station, although inquiries elicited the fact that the fire had occurred during a thunderstorm. A signalman walking along the line towards the station said he did not see the lightning strike there, although he was looking that way and saw the fire occur. I indicated two directions, in one of which I thought it probable that some object within about half a mile had been struck at the time of the occurrence; and I was told that a house just about half a mile away and in one of the two directions I had indicated, had been struck, and, it was believed, at precisely the same time. What no doubt happened was this: When the lightning struck the house the discharge passed away in all directions; the portion going in the direction of the station was in due course more or less concentrated along the gas-pipe leading to the station; the potential of this pipe, terminating near the roof of the foot bridge, was raised, but that of the roof, which was insulated, remained normal; thus a difference of potential was created, which was sufficient to cause a spark between the two, across the gap between the pipe and the insulated wires, and this spark ignited the covering of the wires and caused the fire.

In this type of case there is no metallic connection between the buildings; the earth carries the wave or impulse. Whatever the object the discharge strikes, and whatever resistance it meets with, it must go to good earth, and the earth forms the conductor that carries the wave or impulse to the second object. All that is required at what I may call the receiver end is the suitable arrangement of metal to produce the difference of potential that will cause a spark. In the instance under reference it was the gas-pipe passing along the road from the direction of the struck building (but not actually from that building) and the long length of corrugated iron roofing insulated from the ground on a wooden frame. The spark could have been prevented by making a proper connection between the iron roof and the gas-pipe, or by placing the telegraph wires so that they should not form a partial connection. It is not only one "earthed" and one insulated metal that would cause such a spark. Two "earthed" metals, such as a gas-pipe and a water-pipe entering a building from opposite directions and on opposite sides, and crossing or closely approaching one another inside the building, would be liable to cause a spark; and when they do enter from opposite sides in this manner (rather unusual) the case wants looking into very carefully.

Methods of Protection.—We may say broadly that there are three methods of protection that might be adopted. Firstly, there is the cage system. If you have a metal box you can get no electrical effects in the interior, and if a building could be metal plated, so as to be like a biscuit tin with the lid on, it would be quite lightning-proof, but no metal must be allowed to pass into the interior without being first connected to the metal sheathing. The advantage of this method would be that no knowledge of the subject and no study of the problem involved by the complications of metal in the structure would be necessary. It is par excellence the novice's method. It is not even necessary to cover the building with continuous sheets of metal; if conductors were arranged so as to form a closed meshed network all over it—so as to make it resemble a bird cage—it would still form a screen against effects in the interior.

The second method is to connect every particle of metal in and about the structure to one another and to the conductor system. Then no sparking or side-flash would occur, because there would be no gaps between metals where, owing to difference of potential, sparks could occur. This method is the one attempted by Trinity House for lighthouses, but for ordinary buildings it is impracticable also.

The third method, which I regard as the practical one, gives, I think, the maximum of efficiency with the minimum of cost; but it necessitates a profound study of the subject and very careful consideration of the buildings to be protected. First, one must determine what are the parts of the building liable to be struck, and run continuous lines of metal from

these to good earth connections, either as main conductors or as mains and branches, as may be most effective; then one must consider the effect that would occur if either of those conductors was struck by lightning, and make connections across any sparking gaps, either between the conductor and other metals, or between those other metals themselves, if the sparks were calculated to do harm. There are some metals about a building that should not be brought into connection with the conductor system, and these should be carefully avoided by giving the conductor a course that is beyond sparking distance. The question as to what shall and what shall not be connected is the most difficult one of all to decide, and no fixed rule can be laid down; it must be decided by the problem found to be involved.

I have devoted the time at my disposal to the points I regard as of paramount importance, but you would probably consider my remarks incomplete if I did not refer to the relative value of copper and iron for conductors. So far as regards conductivity and dissipation of energy, the matter is, I consider, of such trifling importance that it sinks into insignificance in comparison with considerations of durability. A conductor is expected to last a long time, and iron, even if galvanized, is very perishable; so we are left with copper as the alternative of these two metals. As regards the advantage of iron dissipating the energy of a discharge, this has been demonstrated experimentally, and such work is often of very great value; but there are cases where it is necessary to take proportion into account.

The experiments that show the superiority of iron show that a thin iron wire about 100 ft. long has a decided advantage in dissipating the energy of a 6-in. spark, but if you were to repeat the experiments with a conducting wire about 1-16-in. long and a 6-in. spark,—which would be about proportional to a lightning conductor 100 ft. long being struck by a lightning flash half a mile in length—you would see what I mean by saying that, in my opinion, the matter is of trifling importance.

A STUDY OF REFUSE DISPOSAL

FROM "THE ENGINEERING RECORD."

On December 18, Mr. J. T. Fetherston, Superintendent of Street Cleaning of the Borough of Richmond, New York City, read a paper before the American Society of Civil Engineers on "Municipal Refuse Disposal; an Investigation," which gives the results of a very elaborate study of this subject, both its general principles and its special features in the borough. The full paper is printed in the "Proceedings" of the Society, vol. xxxiii, page 940. The author made an elaborate study of the quantity, composition, seasonal variations and calorific value of the local household refuse, conducted tests by burning mixed wastes, and investigated many destructor plants. Some of the information gathered by these means is given herewith.

The volumes of the total collection in the borough during any month vary from 8% above to 12% below the average of 3.7 cu. yds. (or 1.6 tons) per thousand inhabitants per day, although the weight varies from 23% above the average in winter to 30% below it in the summer and fall. This weight variation is due to the different proportions of ashes, rubbish and garbage in the different seasons.

Many tests of the compositions of the refuse and of the calorific value of the refuse and of its different parts are tabulated in the paper and from these data the accompanying table of the average fuel value of the refuse was computed. The figures for September are given separately, as the refuse during this month is more difficult to burn than that at any other portion of the year.

HEAT VALUE OF ONE POUND OF REFUSE.

	Calorific Power of Combustible, B. T. U.	Moisture, Per Cent.	Ash, Per Cent.	Combustible, Per Cent.
Spring	4,747	14.03	50.06	35.91
Summer ...	3,477	28.86	39.74	31.40
Autumn ...	3,823	27.74	39.74	32.52
Winter	4,358	13.11	52.72	34.17
Year	4,274	19.74	46.03	34.23
September..	3,295	35.83	33.69	30.48

Many tests of burning the refuse were made at a crematory on a grate of 12 sq. ft. area, and in spite of adverse conditions all tests but one were successful in destroying mixed household refuse, although unburned particles were at times found in the residue. The general

results of these rough practical tests are summed up as follows:

1. Household refuse, as collected in this district, when burned in a properly designed furnace, will be self-combustible, under ordinary conditions, showing higher calorific power in winter than in summer. Screened refuse will give better results in burning than unscreened.

2. About 80 lbs. of refuse per sq. ft. of grate could be burned before it became necessary to remove the clinker.

3. The process may be made continuous by retaining the heated coals from the top portion of the fire and removing the mass clinker. Coal may be required to heat the furnace walls if the operation of the plant is not made continuous.

4. The rate of burning will be higher in summer than in winter.

5. The percentage of clinker will also vary with the seasons, being high in winter and low in summer. The total residue was not determined, as a large portion of the fine ash was carried over by the air blast and could not be recovered.

6. The heat lost by the removal of hot clinker varied from 300 to 500 B.T.U. per lb. of clinker.

7. Street sweepings from this locality could not be burned with household refuse, except when mixed in small proportions.

From the data collected during his investigations and the information furnished by a thorough test of the destructor at Nelson, England, by Mr. C. E. Stromeyer, the author worked out a heat balance for the local refuse of which the leading deductions are given in the accompanying tables of the equivalent evaporation, from and at 212° in pounds of water, and the estimated temperature of the combustion chamber, in degrees Fahrenheit, using the local refuse in a good destructor.

PROBABLE RESULTS WITH LOCAL REFUSE.

	Spring.	Summer.	Autumn.	Winter.	Year.	Sept.
Equiv. evap., lbs.	2.46	1.29	1.68	1.98	2.03	1.02
Temp. degs.....	2,370	1,710	1,950	2,140	2,150	1,550

Summarizing the results of examinations, tests, and experiments when mixed household refuse from the district considered, the following conclusions are derived:

1. Average local refuse differs mainly from what is known concerning average English refuse in the higher percentage of incombustible matter and the lower percentage of water. The average results to be expected in power production are surprisingly high, and the seasonal variations are greater with local refuse than with British refuse.

2. Under expert management, with a properly designed furnace, the process can be carried out in settled communities without nuisance.

3. The average local residue will be greater than the average English residue mainly because of the high percentage of fine ash which will to some extent be carried away from the fire-grate by the forced draft.

4. As compared with the local cost of burning garbage and caring for "ash and rubbish" dumps, the cost of the destruction of mixed refuse will probably be higher, though a proper utilization of the steam generated and the clinker resulting may offset this increase in cost, while a rearrangement of the refuse collection system may tend further to make the cost of the methods comparable.

5. For the particular condition herein considered, mixed-refuse destruction appears to offer the best solution of the problem.

Thirty-nine refuse destructors in Great Britain and one in Canada were visited by Mr. Fetherston, and his paper gives some elaborate summaries of the important facts, concerning them. In comparing American household refuse with British refuse, localities having the same general characteristics and for the same period of the year should be chosen. On this basis, as a general conclusion, the author is of the opinion that British refuse contains more ashes, less garbage, less rubbish and more moisture than household refuse in the vicinity of New York. It would appear that no such seasonal variations occur as may be found in comparing American summer with American winter refuse, while, during the fruit season, British refuse contains no waste comparable to melon rinds, and corn cobs.

That British refuse has a fuel value is proved beyond a doubt by the two hundred or more destructors in which refuse is burned throughout the year without additional fuel. There would seem to be no large seasonal variation in the calorific power of the material. The average evaporation for eighteen tests amounts to 1.62 lbs. of water per pound of refuse.

The location of a plant for the final disposition of refuse has a most important bearing on the cost of the collection (including removal) of the material. Economy in collection requires that the plant shall be centrally located with regard to the district served, and

that loaded collection wagons or carts shall proceed with the road gradient.

Of the forty destructors, four were critically located, so that the least nuisance would probably result in the abandonment of the plants; seventeen were centrally located in advantageous positions with regard to the district served, but the surrounding houses were not in close proximity to the destructors; nineteen were placed on the outskirts of towns and not likely to cause complaint, even if the plants were not well operated. Complaints of nuisance due to the location of British refuse destructors in settled localities are said to be rare, and, as far as could be determined very few of the plants visited deserve condemnation in this respect.

All these destructors visited contain large brickwork chambers having fixed grates with boilers placed outside the refuse-burning portion. In the destruction of refuse by fire, well-determined principles of combustion apply. In practice, the destruction of refuse may be attained successfully by burning it by forced draft in a so-called Dutch oven or chamber where the brickwork is maintained at a high heat, and the escaping gases are subjected to a high temperature with an excess of air for a sufficient length of time to oxidize the combustible constituents of the material.

The forms of British destructors vary, and for convenience may be divided into two general groups.

Group 1.—The first may be termed the mutual assistance type, where one unit contains several grates with divided ash-pits, the products of combustion intermingling in the upper portion of the furnace, thus combining several furnaces or cells in one. Representatives of this type are the Meldrum and Heenan.

Group 2.—The second comprises furnaces in which each burning grate or cell forms a separate unit. The products of combustion either commingle in a general flue or combustion chamber, or pass directly from cell to boiler. Representatives of the cell type in which the products of combustion intermingle in a common chamber before passing to the boiler are the Horsfall, Sterling, and Beaman and Deas (Meldrum). Representatives of the type in which the products of combustion pass directly from the cell into contact with the boiler are the original Fryer, Fryer's Improved (Manlove-Alliott and Company), Warner, and Baker.

The Meldrum, Heenan, and Horsfall types pre-heat the air used for combustion to a temperature from 200 to 400° F. before it comes in contact with the burning fuel on the grate. Other makes of furnaces mentioned in Group 2 use air at ordinary atmospheric temperature. The utilization of heated air undoubtedly tends to more perfect combustion and higher temperatures both in cell and combustion chamber. Other differences in design, in the furnaces in Groups 1 and 2, may be noted, as for instance, the drying hearth which some furnace makers consider essential in the destruction of refuse, the use of steam-jet blowers or fans for forced draft, the different provisions for arresting dust, the kind of boilers used, the various methods of feeding, clinkering, stoking, etc. All the above-named destructors, except the original Fryer, use forced draft, which is considered necessary for the attainment of a high temperature.

The aim in the design of refuse destructors should be to maintain a steady temperature. If it be considered that 1,250° F. is the minimum at which septic poisons in the products of combustion are destroyed, the higher limit of temperature is fixed by the materials used in the construction of the furnace. Temperatures greater than 2,000° F. are apt to result in high cost of repairs. Thus temperatures between 1,250 and 2,000° F. are desirable, both from sanitary and economical points of view. As the burning of refuse in a destructor is an intermittent process, requiring alternate charging and clinkering, the fluctuations in temperature should be minimized as much as possible. When destructors are of such design that the gases pass directly from cell to boiler without an intermediate combustion chamber, there is danger of unoxidized gases being cooled, by contact with the boiler, below the temperature required to prevent nuisance.

In general, modern British types of destructor vary in important details, and, of the different plants examined by the author, those in which a combustion chamber or flue was placed between the cell (or unit) and the boiler, and where heated air was used for combustion, appeared to be doing the most satisfactory work. Of the forty plants inspected, all but two produced steam for power purposes.

Cost of Operation.—The cost of operation was obtained from the engineer or superintendent in charge of the destructor or from the furnace makers. It appears that for twenty-four installations the average cost of labor

per long ton (2,240 lbs.) of refuse destroyed would amount to 24.3 cents, or 21.5 cents per short ton (2,000 lbs.). As the American rate of laborers' wages is about double the British rate, this would make 43 cents per short ton of refuse destroyed on an American basis.

For supervision, only four installations had figures available, the average being 4.83 cents per long ton. Two plants reported the cost for repairs at 3.22 cents per long ton.

Only one complete report was obtained in which all charges for the destruction of refuse, including labor, supervision, interest on capital, sinking fund, repairs and supplies, were included. The total cost of operation, including all the above charges at Stoke-upon-Trent, amounted to $1.17 per long ton or $1.04 per short ton. By changing the labor rate so that it would compare with American conditions, and by assuming the same charges for interest, sinking fund and repairs, it would appear that the total cost of refuse destruction for a plant similar to that at Stoke-upon-Trent would amount to $1.50 per short ton in New York.

Definite information regarding the quantity of refuse handled per man per hour (assuming the quality of labor to be comparable) affords a better general means for arriving at the labor cost of operating a destructor. From the figures for twenty-seven plants, on an average, each man employed would handle 0.78 long ton per hour, varying from 0.5 to 2 tons per hour with the type of plant and method of operation. At an easy rate of working, there should be no difficulty in destroying 0.75 short ton per man per hour; hence, with wages at 25 cents per hour (or $2 per day), the cost of labor would amount to 33⅓ cents per ton, while at 31¼ cents per hour (or $2.50 per day), the cost would be about 42 cents per ton.

It appears that the top-feeding method (except where water-sealed doors are used) allows smoke to escape. Even with water-sealed doors, smoke escapes when charging. Of the hand-firing methods, the front-fed type appears to be advantageous, with regard to concentration of labor and freedom from escaping smoke, but the storage bin cuts off light and air from the firemen, while some refuse may be mixed with clinker if the men are careless. With back hand-feeding by shovel, ample light and air can be given on the clinkering side of the furnace where it is most needed. As compared with front-feeding, back hand-feeding does not permit of the same concentration of labor, but allows greater comfort to the men employed, which more than compensates for this slight disadvantage.

In general, shovel-feeding obviates escaping smoke from top-feeding doors, allows a better selection of refuse, and does away with stoking to a great extent, as refuse can be charged directly on the grate, thus saving one operation in destroying the material. When the refuse has not reached an advanced stage of decomposition, and does not contain an excess of water, or such objectionable material as nightsoil, hand-firing is undoubtedly to be preferred, especially for power plants.

By stoking is meant the dragging, pushing or spreading of refuse after it has been charged into the furnace. All top-fed destructors and all destructors provided with drying hearths require considerable stoking. Hand-fed types, without drying hearths, where refuse is thrown directly on the grate, do not need much stoking.

At first sight, it would seem that refuse charged direct from cart to cell without intermediate handling should prove most sanitary and economical, yet the disadvantages of this method are many. For any particular case a study of local conditions will determine the best system to be used.

Clinkering is perhaps the most trying work in connection with the operation of a destructor. A mass of hot slag must be broken up by long bars, tipped into a wheel-barrow or other conveyance, and removed while in a highly heated condition. The work is performed by hand labor opposite the open doors of a highly heated furnace. There are various methods of conveying clinker, as by wheel-barrows, by cars on rails, or by skips running on an overhead rail. When cars or monorailways are used, the storage room is limited and the place where the material is deposited must be cleared at intervals; for this reason, the system has been abandoned in favor of wheel-barrows at many plants. Various mechanical devices, such as tipping grates, etc., have been tried in order to lessen the work of clinkering, but, up to the present time, all have failed.

As a general rule, the clinker in sight at the various installations was found to be hard and well-burned, except where plants were carelessly operated, or where fires were rushed at some electric lighting stations. In order that clinker shall be dense and that practically all the carbon shall be oxidized, it is necessary that the clinker be exposed to a

high temperature for a sufficient time to consume thoroughly all the combustible material.

In burning mixed refuse, some fine incombustible material finds its way into the destructor flue or dust traps, and must be removed periodically. This may have an important bearing upon the actual capacity of a destructor, as it may be necessary to shut down the plant for several days while the cleaning process is under way. The time elapsing between cleaning periods varies with the character of the material destroyed and the type of destructor. It would appear to be necessary to clean out all flues thoroughly once every 4 to 6 weeks in Great Britain, except where a special dust-catcher is used.

Figures for eighteen destructor tests, giving the quantity of water evaporated per pound of refuse ("from and at 212° F.") for periods varying from 6½ hours to one year were secured. The highest rate of evaporation was 2.66 lbs. of water per pound of refuse, in a 15-hour run at a destructor in a colliery district. The lowest gave 0.88 lb. of water per pound of material, in a test of 11½ days, with refuse containing a large proportion of nightsoil. The average evaporation in eighteen modern destructor tests amounted to 1.62 lbs. of water per pound of refuse. In all the foregoing figures the water evaporated is a gross amount, and in order to obtain the net useful steam produced for power purposes it is necessary to deduct for forced draft apparatus. It appears, from the figures quoted, that, in a district where coal is abundant and cheap, it is possible to evaporate about 2.5 lbs. of water per pound of refuse, while in other districts, distant from coal fields, destructors are capable of producing an evaporation of about 1.5 lbs. per pound of refuse.

THE DEVELOPMENT OF CONTINUOUS CURRENT TURBO-GENERATORS

In discussing this subject in a paper recently read before the Institution of Electrical Engineers, Dr. R. Pohl stated that in order to operate sets at the highest possible speeds it is necessary to know the maximum permissible speed at which an armature of given diameter may be run without undue stress being set up; and also the maximum output thereby obtainable, using an armature axially as long as possible. As the speed limit of an armature is defined by the circumferential velocity for which the tensile stresses reach their permissible limit, it has been found that, using special phosphor-bronze or manganese-bronze castings for the end shells (having a permissible stress of about 8,500 lbs. per sq. in.), the safe maximum circumferential velocity is 246 ft. per min. From this the r.p.m. for any diameter can be easily obtained. The greatest permissible voltage per segment of the commutator, in the case of high-speed generators, is taken at 40 volts, or 2-3 of the value usually employed for slow-speed machines. Assuming a field distortion of 25%, the product of the mean flux through the air gap and the length of the armature is thus limited to about 550,000, which, for a mean flux of 32,250 lines per sq. in., gives 17 ins. as the greatest permissible length of armature, independent of its diameter. Taking the ratio of pole-arc/pole pitch to be equal to 0.65, the total number of lines entering or leaving the armature is found to be: Flux per pole × No. of poles = 1,118,000 d, where d is the diameter in inches. It is also necessary to determine how many ampere-turns can be accommodated on the circumference of the armature. The highest specific load AS (ampere-conductors per inch of armature circumference) may be found from an empirical formula expressing conditions obtaining in well-designed 550-volt machines, viz.: AS = (350d − 2,275) ÷ (d + 2.75). Calculations of outputs and speeds based on the above conditions show that it is impossible to construct a direct-current generator above 500 KW. (the proper domain of the steam turbine) which will meet the requirements demanded by the speed of the equivalent turbine. The discrepancy may be overcome by artificially reducing the speed of the turbine, which increases the cost and the steam consumption; by a tandem arrangement of two half-capacity dynamos coupled to one turbine; by the use of a homopolar generator. The latter is barred because of the difficulty of obtaining sufficiently high volt-

ages, and by the excessive weight of metal required as compared to that of a commutating machine of equivalent capacity. The output can be increased by extending the flash-over and the sparking limits. Since it is not advisable to increase the circumferential velocity, attention must be given to increasing the permissible AS values and in using a shunt parallel to the commutating poles in order to make the characteristic of the commutating field a straight line. There would seem to be no likelihood of improvement in the direction of increased flux unless means are found to enable the armature to be lengthened without exceeding the flash-over limit, and simultaneously without increasing the reactance voltage. This canly only be accomplished, according to Dr. Pohl, by a suitable armature winding, which he describes, but in regard to which results are as yet not available.

An analysis of the operation of a machine provided with this winding would seem to make it possible to predict the construction of satisfactory generators having armatures of twice the present length, and capable of yielding outputs 100% greater than those now obtained.

CAN EARTHQUAKE-PROOF BUILDINGS BE ERECTED?*

By L. MENSCH

The subject of earthquake-proof buildings is a vital one for San Francisco and surrounding counties. It is, of course, possible to building earthquake-proof buildings of brick, stone and wood.

The great majority of well-built buildings of San Francisco stood the earthquake remarkably well, provided that they were not built on what you may call stilts, and where they were properly braced and tied together, nothwithstanding the contrary reports spread all over the country.

Reinforced concrete is the best material adapted to buildings which may have to withstand earthquake shocks, and we can build an absolutely quakeproof reinforced-concrete building at a considerably lower cost than the ordinary steel building whose quakeproof qualities are only problematic. We know to-day, without a scintilla of doubt, what the carrying capacity of a reinforced-concrete beam is, if reinforced by a given percentage of steel, and I positively assert that you cannot predict with the same degree of exactness the strength of a timber beam.

The earthquake of April, 1906, on the ground of San Francisco produced vibrations of an amplitude of less than one-half an inch and a total wave length of about one hundred feet. These vibrations followed each other in various directions and on filled ground caused serious upheavals to the extent of several feet, and set up in all buildings considerable vibration. It is clear that the upper parts of a building vibrated with a much greater amplitude than the lower portions and that these vibrations in regard to amplitude depended upon the stiffness of the stories and the connections with the adjacent stories. Assume that the third story of a building was less braced than the second story. The amplitude of the vibrations for the third story was then considerably larger than that of those for the second, with the result that great shearing forces were produced at the connections at the third-floor level. If the connections could not stand these horizontal shearing stresses, a horizontal displacement must have taken place, which may or may not have been followed by failure. Such horizontal displacement you can observe in many parts of the City Hall which are still standing and in other buildings and monuments in the city. That the vibrations depend entirely on the relative stiffness is also clearly shown by the fact that pictures and other objects not in rigid connection with the mass of the buildings were thrown from the walls. It seems therefore advisable in an earthquake country to build buildings as uniform in stiffness as possible throughout the various stories.

Let us now return to the vibrations of the ground. I mentioned that they amounted to less than ½ in. in a wave length of 100 ft. The vertical displacements made themselves felt in half this length, that is 50 ft. Let us

*From a paper read before the San Francisco Chapter, American Institute of Architects.

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now assume a building has walls or columns 16 ft. on centers, the relative vertical displacements of these walls or columns amounts then to only 1-16 in., which is an insignificant amount and certainly can be taken care of without the least cause for uneasiness by either timber, steel or concrete construction. The more or less sudden application of the forces will be equivalent to a relative displacement of perhaps twice this amount, but even one-third of an inch of relative displacement will not as a rule cause undue stresses.

Popularly it is believed that frame buildings are the only proper buildings for an earthquake country because they return, after their vibrations, to their old positions. Mathematically speaking, wood has a coefficient of elasticity of one and a half millions; concrete of two and a half millions; steel of twenty-nine millions. Steel is certainly more perfectly elastic, concrete at least just as elastic as wood and therefore we cannot believe that wood is better adapted on this account. The cause of the better behavior of well-built frame buildings over brick or steel buildings in earthquakes lies in the fact that they are built more uniformly, the various partitions being well connected with the walls, and the whole structure is comparatively very light, therefore the momentum produced by the quakes is very much less than in any other class of buildings and therefore the horizontal shearing force is very much smaller. Now take a well built reinforced concrete building. It is the invariable practice of the competent designer of reinforced concrete buildings to provide at least one or two reinforced concrete cross partition walls, to take care of the wind stresses, when wind pressure enters into the consideration of the design. These partition walls are sometimes objectionable, nevertheless they have to be put in, if the owner wishes to have a building to stand any length of time, or to remain plumb, or to have any factor of safety at all. How much more are such cross partition walls required in a building which is purposed to be quake proof? There is no doubt that the connections of a properly designed and properly built reinforced concrete building are very much stronger than those of a frame building both absolutely as well as relatively in regard to the greater weight of concrete.

Reinforced-concrete walls weigh one-half and often less than one-half as much as brick walls which have to do the same duty, and by the nature of the construction are well connected with the floors. It is of course clear that it is not sufficient to design such a building for static stresses alone. The best built building will not necessarily, if this be the case, be able to stand a serious quake.

I cannot enough warn you, whether you design a concrete or a steel building, not to make your columns too small, if you want your building to be earthquake proof. If it is absolutely necessary to omit all the partitions in the first story of a building, your only reliance and salvation lies in the columns, and if you reduce their stiffness you set your buildings practically on stilts, and their earthquake proof qualities are then more than doubtful.

From time immemorial people have looked to the walls for the stability of buildings. Since the introduction of the skeleton principle in steel and reinforced-concrete construction the walls are merely curtains, and contribute hardly more to the stiffness of the skeleton than the glass panes of the windows, while a concrete wall is able to increase the stiffness of a concrete or steel pilaster from four to ten times the former rigidity. This is speaking of the stiffness of a building crosswise to the direction of the walls.

In the direction of the wall a reinforced-concrete wall probably stiffens the skeleton from one thousand to ten thousand times and more. If a building is not too narrow or not too much cut up we can safely figure that the floor construction will act as horizontal girders to transmit the horizontal shears to the end walls, which, as acting girders of 50 ft. or more in depth, are certainly able to take care of these forces. If the walls have very large openings or if the area of the building is large, you have to adopt reinforced-concrete partition walls, say in distances of fifty feet. You have then a greater stiffness than in a modern steel ship which, as you know, has to withstand shocks greater than other structures we know of.

I promised to prove that you can build a reinforced concrete building which is really earthquake proof for less money than a steel building. In order to do this we have only to compare the cost of the structural parts. It takes about 20 lbs. of steel for each square foot of floor in a steel skeleton building. Add to this about one and a half lbs. of steel for the reinforcing of the concrete slabs of small span, you have a total of 21½ lbs. per square foot. You will have to figure on an average of about seven inches of concrete per square foot for the fireproofing of all columns, girders and for the floor slabs, and you will need at an

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average about two feet of lumber per square foot to do the form work for the fireproofing. If we figure the steel erected and painted at the low figure of $75 per ton, the concrete at 45 cts. per cu. ft., the lumber at $60 per thousand feet erected, taken out and re-used, we get the total cost of $1.19 per sq. ft. of steel skeleton and fireproofing.

In a reinforced-concrete building we shall need an average of not more than seven lbs. of steel, about eight inches of concrete and about three and a half feet of lumber per square foot of floors for the structural part of the building. Figuring in this case much higher unit prices on account of the inexperience of workmen and contractors, and considering that the price of plain steel rods is only $2.20 per hundred f. o. b. San Francisco in carload lots, we will assume the cost of the reinforcing steel placed at $65 per ton, concrete at 60 cents per cubic foot, the cost of the form lumber erected, taken out and re-used at $70 per thousand, we find that the cost of the reinforced concrete skeleton amounts to 88 cents per square foot against $1.19 for steel.

In order to make the skeleton earthquake proof beyond question, we will figure on providing reinforced concrete partition walls and we will assume that the area of these walls is one-fourth of the area of the floors. A reinforced concrete partition costs probably 30 cents per square foot more than a hollow plaster partition, or reduced per square foot of floor this extra expense would amount to 7½ cents per square foot, or a grand total of 95½ cents, for a really earthquake-proof structure, against $1.19 for a steel skeleton building, the condition of which may be serious after an earthquake if not stiffened by similar partitions. In this calculation I have assumed very high unit prices for reinforced concrete construction, which is at present necessary on account of the inexperience of all connected with this construction, but these prices will be liable to a reduction of at least 25% in a year or two, with the perfection of workmanship, and with the experience gained by the contractors. This has been the case in all sections of the United States where concrete construction has been carried on for a few years. I have not taken in account the great savings of reinforced concrete footings over steel beam and concrete footings, which amount to at least 50% of the cost of the latter, nor did I take into account the substantial saving by omitting the false ceiling in concrete buildings where square panel construction without intermediate beams is the standard of design, and where the beams may be arranged to come in the partitions, thereby effecting a saving in the height of the stories, and offering a more substantial ceiling than the unsatisfactory wire lath and plaster construction.

THE EXHAUST GASES FROM PETROL MOTORS

By PROF. F. W. BURSTALL

FROM THE "TIMES (LONDON) ENGINEERING SUPPLEMENT."

It is a matter of common knowledge that very frequently the exhaust products from motor-cars have a very strong and disagreeable odor. It is commonly accepted that this is a necessary evil, whereas it is in reality a matter which could be entirely avoided with suitably-proportioned motors. To understand the reason for this objectionable smell, it is necessary to consider in some detail how the petrol is burnt in the motor. Petrol is a mixture of hexane and pentane, having roughly the chemical formula $C_7 H_{16}$. In the carburettor the liquid is converted partly into vapor, and also, due to the very rapid suction, some of the liquid gets carried over in the form of a very fine mist or spray.

The way out of the difficulty is in the first instance to so arrange the carburettor that it is impossible to get anything but petrol vapor into the engine cylinder, and in the next place to insure that there is always a considerable amount of free oxygen, in which case combustion will be absolutely complete before the exhaust valve opens, as is the case with a gas-engine. In gas-engine practice one method of increasing the charge weight is to force a current of cold air through the motor on the exhaust stroke, which not only clears out the

products of combustion, but also cools down the cylinder walls. This has received the name of a scavenger charge, and it has proved to be a thoroughly reliable method of working. Its application to the petrol motor is somewhat difficult, owing to the speed, but one of the methods that has been carried into practice is to modify the ordinary four-stroke Otto cycle into a six-stroke, the two additional strokes being taken up in drawing in a charge of cold air, and expelling it on the second stroke. Experiments on a six-stroke motor showed it to be highly economical in fuel and to give an exhaust both colorless and odorless, and on analysis no trace of even carbon monoxide could be found in the exhaust gases, as there was some 6% of free oxygen present. It would appear that, in cases where extreme lightness is not essential, but where it is important to omit noxious gases, such a motor would be very useful, but, of course, the four-stroke motor can be arranged to run with an equally good exhaust, if the power were reduced so that there was always a considerable excess of oxygen.

The cooling action of the scavenger charge is also well marked, as in one test only some 37% of the heat of the petrol passed into the cooling water, and the petrol consumption per brake horse-power was 0.66 lb.

HYDRAULIC PROPERTIES OF REGROUND CEMENT MORTARS

Having observed in the course of their microscopic examination of cement mortars that a large proportion of the cement was unacted upon by water even after submergence for long periods, Messrs. Henry S. Spackman and Robert W. Lesley decided to determine by actual test the extent of the hydraulic properties remaining in the cement after it had been gaged with water and allowed to harden. Standard briquettes of neat cement and of 1 cement to 3 sand were made from carefully selected samples of a well-known brand. These were tested for tensile strength and the broken briquettes were then stored in air in a cellar, and later dried, crushed and reground. Briquettes were then made from this material, and in turn tested, stored, dried and reground for a third set of tests. A rough indication of the strength of the cement after such successive treatments can be had from the following averages of the results of tests 28 days and over.

TENSILE STRENGTH OF STANDARD BRIQUETTES.

	1st Test.	2d Test.	3d Test.
Neat	700 lbs.	350 lbs.	210 lbs.
1 C : 3 S.....	375 lbs.	160 lbs.	110 lbs.

The results of these tests were presented in a paper read at the recent annual convention of the Association of Portland Cement Manufacturers, and go to show that even after cement has been twice gaged with water and allowed to harden under water, that all the cementing and hydraulic qualities are not destroyed, and that gaging with water and submergence in water does not retard the setting time of the reground cement as much as would be expected. Indeed, in the first test the setting time of the cement on being reground was quicker than in the original sample. A third conclusion is that it is only the very fine flour in the cement that is in condition to react when gaged with water and to give strength to the mortars.

The fact that the sieving tests do not determine accurately the percentage of flour has been recognized in Europe, and various devices are being experimented with to determine this percentage. These investigations also show conclusively that all commercial cements contain a large amount of inert material and that the cement manufacturer is quarrying, grinding, burning, grinding again and paying freight upon from 50 to 60% of inert material which could as well be replaced by sand. Under present mechanical conditions it is commercially impossible to grind much finer than we are now doing, but one of the economies of the future in cement manufacture will be brought about by the perfection of grinding machinery that will avoid the waste above mentioned.

CAST IRON MIXTURES: THEIR PROPERTIES AND CALCULATIONS*

By W. J. KEEP

Following are chemical compositions and physical qualities desirable in iron for various kinds of work, and some mixtures that will give them:

HARD IRON FOR HEAVY WORK.

Castings for compressor cylinders, valves, high-pressure work, etc.

Chemical composition: Silicon, 1.20 to 1.50%; sulphur under 0.09%; phosphorus 0.35 to 0.60%; manganese, 0.50 to 0.80%.

Physical qualities: Transverse strength of a test bar 1 in. square and 12 ins. long, 2,400 to 2,600 lbs.; tensile strength of same bar, 22,000 to 25,000 lbs.; shrinkage in yokes, 0.160 in.; chill in yokes, 0.25 in.

Mixtures: Steel scrap to the amount of 10 to 25% may be added in the cupola. In a foundry running both air furnaces and cupolas, for castings of over 15 tons, one-half of iron from each may be mixed in the ladle to give strength. When the amount of steel exceeds 10% a very small quantity of aluminum should be used in the ladle to increase fluidity. It will remove all gases, prevent blow holes, and give a very close grain. A piece of pure aluminum wire ⅜-in. in diameter, and 1 in. long, for each 100 lbs. of iron, is sufficient; do not use so called "casting aluminum." To insure a perfectly sound interior make large castings as hard as will allow of machining, by keeping the silicon as low as possible. Select close-grained foundry iron low in silicon, or mill iron if the grain of the foundry grade is too coarse. A close grain in pig iron accompanies a higher sulphur content which is due to a cold furnace. Charcoal pig iron gives a close grain with low sulphur.

Although using scrap closes the grain, use it sparingly for the strongest castings—sometimes not more than 10%, to avoid introducing sulphur. It is safer to use close-grained pig, and steel scrap. For extra strength, use 1 to 10 lbs. of ferro-manganese, either in lumps in the cupola or granulated in the ladle.

The best way to close the grain and prevent sponginess is to charge 100 lbs. of cast-iron borings with each ton of the mixture packed solid in a covered wooden box 6 ins. deep. The box settles down to the melting point before the wood burns, and then the borings melt and mix, without more than 10% loss. Steel borings and chips can be used instead, but aluminum is needed in the ladle. Do not mix cast iron and steel borings in the same box.

In calculating mixtures for heavy castings, allow 1.50% silicon and 0.10% sulphur to be contained in the scrap.

MEDIUM IRON FOR GENERAL WORK.

Castings for low pressure cylinders, gears and pinions, etc.

Chemical composition: Silicon, 1.50 to 2.00%; sulphur, under 0.08%; phosphorus, 0.35 to 0.60%; manganese, 0.50 to 0.80%.

Physical qualities: Transverse strength of a test bar 1 in. square and 12 ins. long, 2,200 to 2,400 lbs.; tensile strength, 20,000 to 23,000 lbs.; shrinkage 0.154 in.; chill, 0.15 in.

Mixtures: Nos. 1, 2 and 3 foundry iron. Home and foreign scrap up to 50% of the whole is allowable for the best castings; or more with carefully selected scrap. In calculating mixtures allow 1.75 to 2.00% silicon and 0.10% sulphur in foreign scrap.

SOFT IRON.

For general car and railway castings, pulleys, small castings, and agricultural work.

Chemical composition: Silicon 2.20 to 2.80% (with less the castings are hard, and with more they are too weak). For large castings, 2.40% is a good average; sulphur under 0.85; phosphorus under 0.70; manganese under 0.70.

Physical quantities: Transverse strength of a test bar 1 in. square by 12 ins. long, 2,000 to 2,200 lbs.; tensile strength, 18,000 to 20,000 lbs.; texture: To close the grain use as high a percentage of scrap as will give soft castings.

IRON FOR FRICTIONAL WEAR.

Castings for brake shoes, friction clutches, etc.

Chemical composition: Silicon, 2.00 to 2.50%; sulphur under 0.15%; phosphorus un-

*From a paper read at the Dec., '07, meeting of the American Society of Mechanical Engineers.

der 0.70%; manganese under 0.70%. The addition of spiegeleisen increases hardness.

CALCULATING THE COMPOSITION OF AN IRON MIXTURE.

A variation in silicon will make castings either hard or porous. The grain of the pig and the fracture of scrap are generally reproduced in the casting. The seller of pig iron will give a close approximation to the chemical composition of his iron. The ordinary founder will not employ a chemist to make exact determinations.

Whether the founder uses the approximate or the accurate determination of his irons, he should calculate the chemical composition of his mixture.

Make up on paper the desired mixture, using irons in stock and figure from the analysis, or estimate, of each pig iron, the previously calculated composition of the home scrap, and the estimated composition of the foreign scrap. Multiply the pounds of each iron used by its percentage of silicon to obtain the pounds of silicon, and divide the aggregate weight of silicon in all the irons by the total weight of iron used, thus obtaining the percentage of silicon in the mixture. Deduct 0.20% for loss in melting. The remainder is the silicon in the casting; and if this is too high or too low to produce the desired percentage, vary the irons and figure again; and so on until you secure a mixture that will be satisfactory.

To arrive at the composition by one calculation: If you are forced to use certain irons, determine their weights by considerations of economy, or of stock on hand (for example, enough home scrap to prevent accumulation; enough foreign scrap to cheapen the mixture or to close the grain, and the desired pig irons) and compute the total silicon as before. Then adjust the percentage of silicon in the mixture by calculation from two pig irons, one lower and the other higher in silicon than the percentage just computed, as shown in the following example.

An actual stove plate mixture was desired having 3.50% silicon in a charge of 3,000 lbs. The chemist's analysis card had accompanied each car of pig iron. In this case no foreign scrap was used.

	Weight in pounds.		Per cent. Silicon.		Pounds Silicon.
Home scrap	900	×	3.25	=	29.25
No. 1 foundry	400	×	2.50	=	10.00
No. 2 foundry	350	×	2.18	=	7.63
No. 3 foundry	250	×	1.53	=	3.82
	1,900				50.70
	3,000	×	3.50	=	105.00
Needed	1,100	×	4.94	=	54.30

That is, we needed 1,100 lbs. of an iron having 4.94% silicon to balance the mixture.

We had in stock No. 1 soft with 2.95% silicon, and Ashland silvery with 7.00% silicon; which balanced for the 4.94% as follows:

	Differences.		Balances.	Total Parts.
4.94 No 1 soft	2.95	−1.99	206	405
Ashland silvery	7.00	+2.06	199	

1,100 ÷ 4.05 = 2.72 lbs. = 1 part.
206 × 2.72 = 560 lbs. of No. 1 soft needed.
199 × 2.72 = 541 lbs. of Ashland needed.
Take 550 lbs. of each to make even weights.

This example will fit almost any foundry condition. The result can be checked by computing the silicon in each iron as follows:

550 × 2.95 = 16.225
550 × 7.00 = 38.50
1,900 = 50.70

3,000 × 3.51 = 105.42

Allowing loss of silicon 0.20 gives 3.31% silicon in the casting. The actual analysis was 3.34%.

If, on the other hand, you have plenty of each of the irons in stock and do not care what proportions you use, calculate as follows:

	Differences.	Balances.				Parts	Total parts.
Home scrap	3.25 −0.25	350				350	
No. 1 foundry	2.50 −1.00		350			350	
No. 2 foundry	2.18 −1.32			350		350	2,250
No. 3 foundry	1.53 −1.97				350	350	
No. 1 soft	2.95 −0.55				350	350	
Silvery	7.00 +3.50	25 + 100 + 132 + 197 + 55				509	

3,000 lbs. = 2,250 parts. 1 part = 1.328 lbs.

Iron.	Parts.	Weight.
Home scrap	350	464.8 lbs.
No. 1 foundry	350	464.8 "
No. 2 foundry	350	464.8 "
No. 3 foundry	350	464.8 "
No. 1 soft	350	464.8 "
Silvery	500	676.0 "
Total		3,000 lbs.

But you can only weigh differences of 50 lbs., so divide the 3,000 into multiples of 50. If you wish to do so, use 650 lbs. of home scrap.

Proof.

650 × 3.25 = 21.125
450 × 2.50 = 11.25
450 × 2.18 = 9.81
450 × 1.53 = 6.88
450 × 2.95 = 13.28
650 × 7.00 = 45.50

3,000 × 3.59 = 107.84

LOSS OF IRON IN REMELTING.

The following is the only reliable published data on remelting losses of which the author knows:

In a cupola lined to 52 ins. one ton each of several different irons were melted at one time with the results given below. No iron was thrown away, and the data are reliable.

	Kind of Iron.	Pounds loss per ton.	Per cent.
A	No. 1 Cherry Valley Pig (Si. 2.70 per cent. S. 0.015 per cent.....	95	4.75
B	Cleaned new stove plate.....	159	7.95
C	Cleaned sprues from stove plate.....	130	6.50
D	New stove plate with sand on.....	230	11.50
E	New sprues plate with sand on.....	280	14.00
F	Old stove plate scrap (rusty).....	227	11.35

By pickling with hydrofluoric acid it was found that 33 pounds of the 95 pounds loss of A was sand purchased on the pigs. Milling a ton of F just as purchased showed that 50 pounds of the 227 pounds loss was rust.

REINFORCED CONCRETE FOR FIRE-RESISTING BUILDINGS

By JAMES SHEPPARD

CONDENSED FROM "CONCRETE AND CONSTRUCTIONAL ENGINEERING"

Natural laws, applicable to the different materials used in reinforced concrete, need to be considered and adequately provided for when constructing buildings intended to be fire resisting.

Much has been made of the fact that the coefficients of expansion and contraction of steel and concrete under changes of temperature are practically the same, but from the relative position of these materials when combined in reinforced concrete, as well as from their wide difference of heat conductivity, they do not reach equal temperatures at the same time when subject to fire from the burning of goods stored in buildings constructed with the materials named.

In a laboratory test concrete in one of the beams under test expanded longitudinally in the length of 6 ft., ⅝ in. more than a ¾-in. diam. steel rod embedded therein, the difference in expansion being obviously influenced by the location of the steel rod. Other instances could be presented.

Steel, according to the best authorities, commences to lose its power of resistance to stress at a temperature of about 400° F., and at 770° F. loses 50% of such resistance, becoming plastic at less than 1,000° F.

Concrete depends for its permanence and strength on the existence of water-carrying crystals, formed as the cement sets and hardens, binding the aggregates into one mass. The water necessary for the maintenance of these crystals, and consequently for the strength of the concrete, is gradually decomposed on being subjected to a temperature of 600° F.

As a result of these inevitable laws, concrete, even when made with good cement and aggregates of suitable materials and size, gradually deteriorates when subjected to a temperature of 600° F., and steel also at a temperature of about 400° F.

It is, therefore, of the utmost importance to provide ample protection so that the temperatures named may not reach any part of the concrete or steel needed for structural stability under full loads, which loads, in the event of fire amongst the good stored, would be materially increased by water used to extinguish or prevent the spread of fire.

The corrosion of steel in reinforced concrete appears to result from voids occurring in the concrete more than from the nature of the aggregate used. To secure full resistance to fire it is also important that the concrete be solid throughout.

In office, domestic, or other buildings, which would not be subject to a continued high temperature on the burning of their contents, a moderate addition to the thickness of concrete needed for structural purposes may be sufficient, especially if porous aggregates, which have been found to delay the decomposition of water, are used for the outer portions of the concrete.

In buildings of this class 1½ ins. to 2 ins. of concrete for beams, and 1 in. for small floor slabs in front of all metal work, as stated in the Report of the Royal Institute of British Architects, may be sufficient, but even in such buildings further protection for heavily-loaded girders and columns and floor slabs of large area is desirable.

In extensive buildings used for the storage of large quantities of combustible goods full protection is needed, both for the concrete and the steel, if reliable resistance to fire is required.

The burning of the contents of such buildings produces very high temperatures and most severe conditions, to meet which more perfect protection to the structure is required than that before referred to. The probable displacement of steel members when ramming the concrete needs also to be considered.

For buildings of this character a minimum cover of 1½ ins. to 2 ins. for floor slabs, according to their area, load and position, and 3 ins. for beams, girders and columns, is needed to secure reasonable protection against serious deflection or collapse under the action of fire, and for providing the effective "passive resistance," admitted to be of the greatest importance.

The concrete composing this cover should be made with an ample quantity of good Portland cement, and aggregates of suitable material and size.

Capt. Sewell, of the United States Army Engineers, whose experience with regard to concrete structures under fire is most extensive, recommends, in a report to his government, a minimum thickness of 4 ins. in front of all metal work, and favors the use of the right kind of burned clay for the outer portion of such protection.

There is no practical difficulty in providing and fixing porous terra-cotta, molded so as to be securely keyed into the concrete as this is placed in position, and doubtless the best results would be secured by such an arrangement which would allow of the use of "natural aggregates" giving the greatest strength.

In regard to the matter of the thickness of divisional structures, it should be noted that floors simply separate portions of the same building, and can be readily flooded with water, effectually preventing serious increase of temperature on their upper surfaces, but walls separate distinct buildings, and their surface can be flooded like floors; for this and structural reasons it is necessary for due protection that party walls should be much thicker than floors.

A structure in concrete 4 ins. thick, containing a large proportion of steel, would be much less fire resisting than a similar structure 5 ins. thick containing a smaller proportion of steel. This is shown by the result of one of the recent official tests of the British Fire Prevention Committee with a deep concrete floor having a very small proportion of steel reinforcement.

TESTS OF BOND BETWEEN PLAIN STEEL BARS AND CONCRETE

A series of tests employing both round medium steel and high-carbon steel bars was recently made by Prof. J. L. Van Ornum at the testing laboratory of Washington University, St. Louis, at the instance of the Board of Appeals of the building department of that city.

From an article written by Mr. R. L. Viterbo, in a recent issue of "Engineering-Contracting," we abstract the following facts of interest.

The bars, ranging in diameter from ⅛ in. to 1¼ ins. were imbedded in concrete prisms of a uniform 12 × 12-in. cross-section, the length of imbedment being 25 times the diameter of the bar for medium steel bars, and 40 times the diameter for the high-carbon steel bars. The concrete was a 1:2:4 moderately wet mixture of Red Ring cement, Mississippi river sand and gravel. The tests were made 90 days after the bars were imbedded in the concrete prisms.

All of the tests showed that the first slip occurred shortly after the elastic limit of the steel had been reached, and further, that after the bond proper had been destroyed there still remained a considerable skin friction—in no test less than 200 lbs. per sq. in. of bar surface. The maximum bond obtained per square inch of surface in contact was 460 lbs. for medium steel (minimum, 370 lbs.), and 470 lbs. for high-carbon steel (minimum, 330 lbs.).

As the allowable tensile stress on a bar is taken at 40% of its elastic limit, if we assume an allowable safe bonding stress of 80 lbs. per sq. in. of contact, the friction of 200 lbs. per sq. in. gives a factor of safety of 2½, in case the bond from any reason is prematurely destroyed.

Biographies

Members of the Executive Committee

Mr. Ernest Bevin

Mr. C. R. Attlee

on the construction of a bridge over the Schuylkill River. This turned his attention to bridge work, which was soon to become his life work.

In 1864 he entered into partnership with A. B. Burton, and the firm soon made a name for itself, building many large and important bridges in the East. About ten years later he became President of the Delaware Bridge Company, a newly organized concern, and remained in this office until 1884, when the company was dissolved and Mr. Macdonald, with several other well known bridge engineers, organized the Union Bridge Company. Many notable bridges were built by this firm, among which are the Poughkeepsie Bridge and the Hawkesbury Bridge, in New South Wales. In 1900 the Union Bridge Company was merged with the American Bridge Company, which soon after became one of the constituent companies of the United States Steel Corporation.

Some years ago Mr. Macdonald retired from active business life, and last fall he returned to Gananoque, and has again become a resident of the town of his boyhood.

MINARD LAFEVRE HOLMAN.

Minard Lafevre Holman, who has just been chosen as the head of the American Society of Mechanical Engineers for the coming year, was born in Mexico, Maine, in 1853. When he was but seven years old his parents moved to St. Louis, where he received his early education in the public schools. After graduation he entered the Engineering Department of Washington University and completed his course there in 1874, receiving the degree of Civil Engineer.

From the time of his graduation until 1877 he was engaged in architectural work in Washington, D. C., and St. Louis. In 1877 he accepted a position as a draftsman in the Water Department of St. Louis, and in 1887 became the City Water Commissioner, having charge of the entire water system of the city. Many reforms were inaugurated in the city's water supply by Mr. Holman, chief among which was his installation of new boilers and pumping engines. These have resulted in saving the city about 80 per cent. of its former fuel bills.

In 1899, his third term as Water Commissioner having expired, Mr. Holman went into private practice as a consulting hydraulic and mechanical engineer. In 1900 he became General Superintendent of the Missouri Edison Company, which position he held until four years ago, when he again took up consulting work, associating himself with John A. Laird.

Mr. Holman occupies an unusual position in the engineering fraternity. Eminent as an hydraulic and civil engineer, at the same time he has made a wide reputation for himself as a mechanical engineer. In 1903 he was elected Vice-President of the American Society of Civil Engineers and to the same office also in the society of which he has just been elected President. Such honors, conferred by societies whose work differs so widely, indicate Mr. Holman's remarkable versatility and activity as an engineer.

As an hydraulic expert he holds a most enviable reputation. He has been consulting engineer on the water supplies of many of the large Western cities, notably Denver, Omaha, Kansas City and Cincinnati.

Mr. Holman has contributed many papers of value to the proceedings of both the national and St. Louis engineering societies, and is a clear and fluent writer.

JOHN HAYS HAMMOND.

John Hays Hammond, the new President of the American Institute of Mining Engineers, was born in San Francisco, in 1855. His early education was received in private schools in California, and in these he prepared for Yale. He graduated from the Sheffield Scientific School in 1876 and later took a three years' course in the School of Mines of Freiburg, Saxony.

During the year 1879 Mr. Hammond was engaged on work for the United States Geological Survey and in 1880 established himself as a consulting mining engineer, which practice he continued for the next thirteen years, gaining for himself a wide reputation as an expert. In 1893 he left the United States for South Africa and there acted as consulting mining engineer for the British South Africa Company, the Radfontein Estates Gold Mining Company, the Consolidated Gold Fields of South Africa, and to Cecil Rhodes. His connection with the Reform Movement in the Transvaal, after the Jameson raid, with which Mr. Hammond was not in sympathy, led to his arrest and trial for inciting treason and rebellion. He received the death sentence, but this was soon after commuted to fifteen years imprisonment. He was, however, soon afterwards released on the payment of $125,000 fine.

After his release he returned to the United States and from that time until 1903 was engaged in consulting work. During this period he had many connections with various mining companies, having been a director in several

Dr. Ralph Bunche, Nobel Peace Prize Winner

Dr. Martin Luther King, Jr.

SMITH AND CLARK

Mr. Smith is a native of Ohio, and was born in Cincinnati in 1850. He received his education in the public schools of that city, and at the age of fifteen began his business career as a clerk in a dry goods store. He remained in this position for three years, and then entered the employ of a wholesale grocery house, where he remained for seven years. In 1875 he formed a partnership with Mr. Clark, and they started in business for themselves. They have been very successful, and their business has grown steadily from year to year.

NOTES ON ENGINEERING AND APPLIED SCIENCE FROM ALL SOURCES

Joining Old Concrete to New.—Recent French experiments go to show that the use of a cement wash at the joint is of material value in obtaining a good connection between old and new concrete work. Excessive tamping of the new work near the joint adds appreciably to the strength of the connection, whether the cement wash is used at the joint or not.

Strength of Corrugated Steel Sheets.—Replying to an inquiry in a recent issue of "Engineering News," Mr. George H. Blakely writes to that journal calling attention to a formula derived from one given by him some ten years ago in the Passaic handbook: Safe load on corrugated steel sheets in lbs. per sq. ft. = 25,000 ht ÷ L^2, where h = depth of corrugations in ins., t = thickness of metal in ins., and L = length of span in ft. This formula corresponds to a safe fiber stress of 10,000 lbs. per sq. in.

An Efficient Steam Boiler.—A 335-HP. boiler manufactured by the Rust Boiler Co., of Pittsburg, and tested recently by Prof. William Kent, of Syracuse University, evaporated, according to an item in a recent issue of "Engineering News," 12,216 lbs. of water from and at 212° per lb. of combustible (10.505 lbs. per lb. of dry coal) at 5% above its rating. When forced to operate at 210½% of its rated capacity, the evaporation values were 10.859 lbs. and 9.416 lbs., respectively, per lb. of combustible and dry coal. In the overload test 7.26 lbs. of water were evaporated from and at 212° per sq. ft. of heating surface per hour.

Strength of Flanged Fittings.—From numerous tests made by the Crane Co., of Chicago, and described in a recent issue of "The Valve World," the bursting pressure (B) for tees and ells, in lbs. per sq. in. = ST ÷ D, where T is the thickness of the metal in ins., D the inside diameter in ins., and S = 65% of the tensile strength of the metal for fittings up to 12 ins. diameter (for larger sizes, 60%). For working pressure divide the bursting-pressure by a safety factor of 4 to 8. Fittings of both cast iron and ferro-steel were tested; the cast iron had a tensile strength of 22,000 lbs. per sq. in., and the ferro-steel a tensile strength of 33,000 lbs. per sq. in.

Mixtures for Sprinkling Road Surfaces.—A mixture of soapsuds, petroleum and water has been sprinkled on the roads of Boston's park system and according to reports very satisfactory results have been obtained. The road surfaces treated with this mixture required less sprinkling with water than those which had not been treated. By combining the oil with soapsuds and water it can be applied without annoyance to users of the roads; in fact, the mixture seemed to help the oil to penetrate into the road instead of remaining on the surface. Cottonseed oil soap, Texas petroleum and water were used. The asphalt in the Texas oil binds the road surface and lessens the cost of repairs.

The Power Cost of Elevating Material.—According to Walter B. Snow, in the "American Machinist," the cost of elevating material does not lie in the power expended, and the decision regarding the number of floors in a multi-storied building is therefore to be based upon other factors than the cost of power for that purpose. Taking one instance, of a firm lifting 100,000 tons in the course of a year through an average distance of 25 feet, he shows that the annual expenditure for power alone would only be $2.52. It is easily seen, therefore, that the cost of lifting through an additional story is no reason at all for omitting that story. The power equipment and the elevating mechanism vary but slightly for any reasonable number of stories above the ground floor.

Efflorescence on Concrete.—Efflorescence is a name applied to the yellow or white accumulations which frequently appear on concrete surfaces. These deposits on the surface

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are due to the fact that certain salts leach out of the concrete and form in thin layers where water accumulates on the surface. These salts are, as a rule, sulphates of calcium and magnesium. Both salts are found in many cements and are slightly soluble in water. To prevent their appearance on the surface of the concrete it would be necessary to use cements entirely free from them, but this is such a difficult matter that it would hardly pay for engineers to discriminate against cements which contain these soluble salts. Hydrochloric acid was recently employed with good results to remove the efflorescence from the surface of a concrete bridge at Washington, D. C. The acid was diluted with four to five parts water and the surface was cleaned with ordinary scrubbing brushes. Water was constantly played on the surface to prevent the penetration of the acid. The cost was about 60 cents per square yard. Acetic acid was also tried, but was found less effective than hydrochloric.

The Strength of Rings has been the subject of considerable correspondence in the columns of recent issues of "The Engineer," London. For ordinary lifting rings of circular cross-section, such as are used in connection with chains and crane hooks, the maximum stress is

$$f = 1.62\ W\ (D + d) \div d^3,$$

where W = load supported by ring in lbs., D = inner diameter of ring in inches, and d = the diameter of the iron or steel of the ring in inches. As lifting rings are frequently subjected to suddenly applied loads, a factor of safety around 10 should be used for a ring worked up from the solid; 13 to 15 for a welded ring, assuming efficiency of weld to be from 60 to 75%. Thus, a ring 6 ins. in internal diameter to sustain 2,000 lbs. [assuming f (safe) = 4,000 lbs.] should be made from stock approximately 1⅞ ins. in diameter.

Burning Pulverized Coal.—In general, the slight additional cost for pulverizing is more than offset by the relatively higher price in most localities of either fuel oil or natural gas. In such special locations, for applications in which ordinary coal is impracticable, no fuel is as cheap as pulverized coal. Considerations of speed in production have led in metallurgical and other establishments to the widespread use of oil or gas even at a cost per heat-unit twice as great as that of coal. Powdered coal would be equally convenient and quick, and far more economical, for the operation of varnish kettles, annealing furnaces, drop-forge furnaces, brass foundry crucibles, enameling furnaces, cable-coating machines, flanging furnaces, steam-hammer furnaces, rivet and bolt heaters, etc. The only possible competitor of powdered coal in these applications would be industrial gas. For the steam automobile, the dispensing of dust fuel from established depots would effect a saving of about 90% in the cost of fuel, would permit of perfect regulation from outside, continuous and automatic feeding of fuel, high efficiency, smokelessness and cleanliness.—Wm. D. Ennis, in "The Engineering Magazine."

The Durability of Concrete.—In a recent editorial in "Engineering-Contracting" some interesting statements are made regarding the durability of concrete. The writer speaks of the trouble all builders using cut-stone masonry experience, owing to the expansion of the stone and the consequent compressive force which is exerted on the mortar. This force is so great that mortar in cut-stone masonry is sure to crumble, and thus its efficiency in binding the stone together is reduced to a minimum. On the other hand, concrete, even though made with stone far inferior to regular building stone, is much more durable than masonry. In proof of this need only be cited the fact that Roman concrete, built before the beginning of the Christian era, is found in an excellent state of preservation to-day, despite the fact that the Roman cement was far inferior to the Portland cement of the present time. The reason for the durability of concrete is found in the fact that the stone forming the ballast is surrounded on all sides by cement, which protects it from atmospheric changes and envelops and strengthens the stone so that it cannot splinter and crack under the changes of temperature to which it is subjected. As a result of this protection afforded by the cement, stone so poor that it would soon go to pieces if used in masonry will last practically forever if used as the ballast of concrete.

BOOK DEPARTMENT

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ITS DEPARTMENT OF TECHNICAL LITERATURE

By EDWARD F. STEVENS*

The conspicuous advances that have been made in the mechanical and engineering branches of industry during the last thirty years have been accompanied by a rapidly developing literature which embodies the researches of scientists, the record of engineering achievements, the cumulation of data and calculations from years of exact experimenting, and the facts of the discovery and development of new applications of scientific principles. The improvement in the character of technical periodicals has kept pace with the growing quality of the books. A merely superficial comparison of a present-day engineering paper with a standard artisan's journal of 1870 is most instructive and convincing. And so it has come about that those in charge of public libraries have begun to perceive that a collection of books designed to promote the well-being of a people should include, even to the point of specializing, a well rounded assortment of material dealing with the arts of industry. Early experiments in this direction revealed unexpected conditions created by the very nature of the new literature, and the kind of people to whom this literature appealed. It was found that such books, if kept at all, should be kept up

APPLIED SCIENCE REFERENCE ROOM, PRATT INSTITUTE FREE LIBRARY.

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to date, that the latest and best works should be accessible at all times and in the same place, that earnest and studious seekers after technical information should be provided with intelligent and sympathetic assistance, that an unusual class of readers should be made at ease in an environment adapted to their susceptibilities, and so on. To meet these conditions the Pratt Institute Free Library in Brooklyn, N. Y., is maintaining a department known as the Applied Science Reference Room. Three years ago the librarian, Miss Isabel Ely Lord, instituted this department by reserving the largest room on the main floor of the library building as a reading and reference room for people whose work related to engineering and the trades, and for students of science and technology in the Institute and elsewhere. The Applied Science Department has since then grown steadily in scope and usefulness until it may now fairly claim recognition as a permanent, if not prominent, factor among the educational forces of the community.

The arrangement and equipment of the room have been studied for the convenience of its users. In open cases along the walls are shelved within easy reach a select library of books chosen as most recent and authoritative in their respective fields. This collection is a comparatively small one and does not circulate, but is always available for consultation; and great care is exercised that it shall be kept abreast of the most recent advances in all departments of applied science. At the same time the lending library is expanding by constant additions of technical books of a practical and important character, often duplicating works in the Applied Science Room—the two departments working together to serve best the greatest number. Tables provided with lamps and comfortable chairs are arranged about the room, and on these are distributed in familiar array technical and trade periodicals grouped roughly by classes and, as far as practicable, in convenient proximity to the books on related subjects. Besides these tables for reading, certain other tables, free from papers and furnished with writing materials, are reserved for those who wish to study, make notes, or consult the cumbrous bound volumes of periodicals or Patent Office reports. The transactions of the chief English and American engineering societies are kept on file, and an extensive and growing collection of trade catalogues, classified and indexed, is within easy reach of those interested. Thus the Applied Science Room hoards a vast amount of technical information. To make this matter accessible and to save the department from risk of lapsing into a mere storage warehouse of such material is the active concern of the librarian-in-charge. An author and subject catalogue of all books in the useful arts and related sciences in the entire library, printed indexes and bibliographies are in constant use; a card index of current technical literature based on the indexes published monthly by "The Engineering Digest" and "The Engineering Magazine," and closely classified under subjects, keeps track of important articles appearing during the course of the year which would otherwise be obscured in files of yet unbound and unindexed papers; records of matters that have required special search are registered and filed in case the questions arise again; book reviews are collated and indexed and the personal services of the head of the department are always at the command of visitors.

The field covered in this endeavor is a very broad one, the people served vary widely in character and attainment, and the limitations of the work are necessarily definite; but this effort of the Pratt Institute Free Library, and similar ones now made by other libraries, to meet a new and insistent demand have received a response so unqualified as to convince those concerned in library work that a department of applied science has now become an indispensable adjunct to a well-proportioned public library.

BOOK NOTICES

THE STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS. — Written and Compiled by a Staff of Specialists. First edition, 1908. New York: McGraw Publishing Co. Flexible morocco; 4⅛ × 6¾ ins.; pp. xx. + 1,283; 1,271 illustrations in the text, with many tables. $4, net.

This work is without doubt the most successful attempt that has ever been made to cover in a single reference manual the broad field of practical electrical engineering. It consists of twenty sections, ranging from 20 to 130 pages in length, which have been prepared by engineers who are thoroughly conversant with the subjects they write upon, and who know from practical experience the sort of information that is most frequently required by those having occasion to use such compilations. To evidence this it is only

necessary to state that the sections on transformers and electric motors were written by A. S. McAllister, Ph. D., that on electric generators by H. M. Hobart, that on transmission and distribution by the late Arthur Vaughan Abbott, that on illumination by Louis Bell, Ph.D., and that on electric traction by A. H. Armstrong. As practically one-half of the sections are fairly extended treatises on their respective subjects, it is manifestly impossible to do more in the space here available than to mention them by title, giving the authors' names and the number of pages devoted to each subject, as follows: Units (Kenyon), 20 pp.; Electric and Magnetic Circuits (Kenyon), 38 pp.; Measurements and Measuring Apparatus (Kenyon), 68 pp.; Physical, Electrical and Magnetic Properties of Materials (Kenyon), 70 pp.; Theory, Construction and Testing of D. C. and A. C. Magnets (Kenyon), 22 pp.; Theory, Design, Testing and Operation of Transformers (McAllister), 76 pp.; Electric Generators (Hobart and Kenyon), 98 pp.; Electric Motors (McAllister), 74 pp.; Primary and Seconary Batteries (Lyndon and Kenyon), 38 pp.; Central Stations: Water-Power Stations (Beardsley), Steam and Gas-Electric Stations (Shaad), 114 pp.; Electrical Transmission and Distribution (Abbott); Mechanical Transmission (Kenyon), 116 pp.; Illumination, (Bell), 58 pp.; Electric Traction (Armstrong), 130 pp.; Electrochemistry (Roeber), 70 pp.; Telephony (Miller), 48 pp.; Telegraphy (Kenyon), 40 pp.; Heating, Welding, Radiography, Power Required by Machine Tools, and Other Miscellaneous Applications of Electricity (Kenyon), 38 pp.; Wiring (Onken), 44 pp.; Standardization Rules, 42 pp.; Mathematical Tables and Statistics, 22 pp. A 53-page index, comprising over 6,000 items, concludes the book. The order of arrangement is thus seen to be: principles, theory, apparatus, generation, transmission, distribution and utilization. Cross references are numerous throughout the work, duplication of matter being in this way avoided as far as possible. The various sections have been brought down practically to the date of publication and many gaps in the literature of the subjects considered are thus filled. This feature alone makes the possession of the work a necessity to every practicing electrical engineer, and the co-ordinated presentation of the subjects treated renders it especially desirable for students and those who have occasion to require concise and clear statements in regard to electrical matters.

THE DISPOSAL OF MUNICIPAL REFUSE.—By H. de B. Parsons, Consulting Engineer, M. Am. Soc. C. E. and Am. Soc. M. E.; Author of "Steam Boilers: Their Theory and Design." New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. x. + 186; 73 illustrations, mostly full-page plates. $2.

In the course of an extended investigation, begun at the instance of the Department of Street Cleaning, of New York City, and having for its purpose the making of certain designs for the disposal of some of the city refuse, the author acquired a considerable fund of data and other valuable information which he herewith presents in concise form. The object of the work, however, is not to present a treatise on the design of destructor apparatus, but rather to state the characteristics of the materials collected, the uses to which they can be put, the quantities that may be expected, and the principles underlying their economic handling. Chapters are included on the following subjects: Climatic, geographical and other conditions; the various classes of waste materials; methods of collecting, sorting and trimming refuse; methods of disposal, including land and sea dumping, plowing into soil, and incineration; various methods of incineration; fuel and other values of refuse, with result of evaporative tests; snow removal; practical incineration, as carried on in New York, English and Continental cities. Tables are given of the classification of city wastes, analyses of garbage, sweepings, etc., statistics regarding collections, and the approximate calorific value of refuse as fuel.

FIELD SYSTEM.—By Frank B. Gilbreth, M. Am. Soc. C. E. New York and Chicago: The Myron C. Clark Publishing Co. Flexible morocco; 4¼ × 6½ ins; pp. 194; illustrated. $3, net.

The extensive contracting business of Mr. Frank B. Gilbreth, widely known as the exponent of the "cost-plus-a-fixed-sum" system of construction, owes much of its success to the adoption of a code of instructions specially devised for the purpose of obtaining the proper, prompt and economical execution of work at the hands of his foremen in the field. The fact becoming known that his construction superintendents and engineers were furnished with such instructions, there was at once the greatest interest aroused on the part of others engaged in general contacting work, who were naturally desirous of obtaining all possible information in regard to the methods whereby

field work was expeditiously accomplished. Learning that pressure had been brought to bear on some of his men to reveal the contents of what were at the time private instructions, as well as a valuable business asset, Mr. Gilbreth promptly, and in a broad-minded spirit, arranged for the publication of these notes and instructions, thus throwing them open to the use of the engineering profession, and in so doing placing himself on record as favoring the utmost publicity in regard to data, methods, costs, etc.

The various forms employed throughout the different stages of work are given, with explicit instructions for their use in ordering materials, checking work, keeping time sheets, etc. Instructions are also given on the mixing of cement and concrete, the handling of forms, use of drills, care of engines, air compressors and hoists, pumping, etc. Throughout the work are interspersed tables and forformulas regarding weights, mixtures, power, and a considerable number of other items of daily recurrence, upon which it is desirable that tested data should be uniformly employed. Contractors desiring to extend their business beyond the purview of their immediate inspection will do well to give up the time required for a careful study of the methods which Mr. Gilbreth has found of avail in handling a large number of contracts at one time which are distributed over a large area of country.

A PRACTICAL HANDBOOK ON THE DISTILLATION OF ALCOHOL FROM FARM PRODUCTS.—Including the Denaturing of Alcohol and a Synopsis of the New Free Alcohol Law and the Government Regulations. By F. B. Wright. Second Edition, Revised and Greatly Enlarged. New York: Spon & Chamberlain. London: E. & F. Spon, Limited. 1907. Cloth; 5 × 7½ ins.; pp. xii + 271; with 53 text illustrations and 7 inserts of plans of distilleries, etc. $1.00, net.

Since the passage of the law removing the internal revenue on denatured alcohol, a number of works treating of its manufacture have been issued to supply the demand for works of this character. Some of these have treated the question from a strictly scientific point of view while others have been intended to serve as practical guides to those expecting to begin to distil alcohol. This book belongs to the latter class. It is an excellent practical handbook and its 250 pages are filled with valuable information covering all phases of the manufacture of alcohol, descriptions of the latest types of stills and much excellent matter on denaturization. The first chapter is devoted to a discussion of alcohol, its various forms and sources, its chemical structure and properties. Chapter II. deals with the preparation of mashes and the process of fermentation. Mashing, gelatinization and saccharification are described in detail. Fermentation of various kinds is discussed, as well as the preparation of yeast and the fermenting apparatus. Chapter III. treats of simple distilling apparatus and in Chapter IV. the author gives detailed descriptions of the modern types of compound stills and their operation. Chapters V. and VI. are devoted to the processes of rectification and malting. The four following chapters deal with the processes of obtaining alcohol from potatoes, cereals, beets, molasses and sugar cane. Chapter XI. treats of alcoholometry in general and saccharometry is also briefly discussed. The author deals with the general arrangement and equipment of distillation plants in the next chapter. Chapter XIII. gives much valuable matter on denaturing processes and mixtures. The last chapter is devoted to the alcohol regulations in the United States. A good index concludes the book, which will undoubtedly find a wide sale on account of the thoroughness of the presentation of the subject with which it deals.

GARBAGE CREMATORIES IN AMERICA.—By William Mayo Venable, M. S., Assoc. M. Am. Soc. C. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. x. + 200; 45 illustrations. $2, net.

This work opens with a brief discussion of the problem of disposing of waste materials, some space being devoted to an analysis of the relative quantities of the various kinds of refuse and the systems employed in collection. Incineration is then taken up and principles are set forth governing the design of crematories for burning refuse without offense. An extended chapter is devoted to descriptions of successful crematories in operation in this country, followed by another on present-day British practice, with particular reference to the utilization of refuse as a fuel for steam production. Materials and methods of construction are then considered in a short chapter, and a few pages are given up to data on chimneys. In the closing chapter the author gives suggestions for the proper design and construction of crematories based on his experience and investigations, and presents a specification embodying his views. Practically

every type of crematory in use in the United States is described, and a list of installations is given in order that interested parties may make personal investigations of their workings when desirable.

METRIC WEIGHTS WITH ENGLISH EQUIVALENTS.—By Hugh P. McCartney. London: E. & F. Spon, Ltd. New York: Spon & Chamberlain. 1907. Cloth; 4 × 3 ins. 50 cents, net.

This little pocket book will prove of use to all merchants, builders, chemists, etc., who have business relations with countries where the metric system is employed as the standard. The tables show, in English pounds avoirdupois, the relative value of weights of from 1 gram to 50,000 kilograms. In addition there are tables giving the equivalents in Troy weight of quantities from 1 gram to 1,000 grams. This set of tables will be of especial use to chemists and apothecaries. The book gains additional value from its convenient size. It can easily be carried in the vest pocket and thus be called on for use at any moment.

THE PRACTICAL DESIGN OF IRRIGATION WORKS.—By W. G. Bligh, M. Inst. C. E., Executive Engineer Indian P. W. Department (Retired). New York: D. Van Nostrand Co. Cloth; 6¾ × 10¼ ins.; pp. 390; 249 illustrations, including 9 folding plates. $6, net.

The object of this work is the presentation of the principles which govern the design of irrigation works in such a manner that engineers not specifically conversant with this branch of practice may, by means of the information thus afforded, be enabled to evolve suitable plans for such improvements. In order to accomplish this the author has adopted a novel procedure, which consists of analyzing the plans of existing and projected works, pointing out their good and bad features and then developing alternative plans in which improvements suggested by the critical study are incorporated. The first four chapters are devoted to a study of the various structures entering into irrigation works, such as retaining walls, dams, weirs, piers, arches, abutments and floors. The fifth chapter deals with hydraulic formulas and tables and their practical application, and includes several discharge tables, based on a new and original theory, which have never before been published. The remaining chapters are given up to a consideration of irrigation works as a whole, and consist of the practical application of the results of the theoretical discussions of the preceding chapters. The titles of these chapters are as follows: Chap. VI.: Submerged Division Weirs; Chap. VII.: Undersluices; Chap. VIII.: Canal Head Regulators; Chap. IX.: Canal Falls; Chap. X.: Canal Regulation Bridges and Escape Heads; Chap. XI.: Canal Cross-Drainage Works; Chap. XII.: Design of Channels; Chap. XIII.: Reservoirs and Tanks; Chap. XIV.: Screw Gear for Tank Sluices and Roller Gates. In Chap. VI. the author presents a new theory in regard to the frictional resistance offered to the creep of water through a pervious substratum compressed by the weight of the superstructure, and applies his conclusions to a number of specific cases.

NEW BOOKS.

Civil Engineering.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Proceedings of the 10th Annual Meeting, Held at Atlantic City, N. J., June 20-22, 1907. Vol. VII. Edited by the Secretary, under the Direction of the Committee on Publications. Philadelphia, Pa.: The Society (Prof. Edgar Marburg, Secy., University of Pennsylvania). Paper; 6 × 9 ins.; pp. 759; folding and other plates, and text illustrations.

BRUECKEN IN EISENBETON.—A Text-book for School and Practice. By C. Kersten. Part II. Arch Bridges. Berlin, Germany: Wilhelm Ernst & Sohn. Paper; 6½ × 9¾ ins.; pp. 147; 356 illustrations in the text. 4 marks; American price, $1.60; or bound in cloth, 4.8 marks and $2, respectively.

EINFLUSS DER ARMATUR UND DER RISSE IM BETON AUF DIE TRAGSICHERHEIT.—By E. Probst. Reports of the Royal Testing Institution, Gross-Lichterfelde West, Berlin. Berlin, Germany: Julius Springer. Paper; 7½ × 10½ ins.; pp. 144; 9 plates and 77 text illustrations. 15 marks; American price, $6.

MATERIALBEDARF UND DICHTIGKEIT VON BETONMISCHUNGEN. — Unter Berücksichtigung der Zusammenstampfbarkeit der Füllstoffe. By H. Nitzsche. Leipzig, Germany: Wilhelm Engelmann. Paper; 7 × 9¾ ins.; pp. 16; two folding plates in pocket. 1.6 marks; American price, 65 cts.

MOVING LOADS ON RAILWAY UNDERBRIDGES. — Including Diagrams of Bending Moments and Shearing Forces and Tables of Equivalent Uniform Live Loads. By Harry Bamford, Assoc. M. Inst. C. E., Lecturer on Engineering Drawing and Design, Glasgow University. London, England: Whittaker & Co. New

York: The Macmillan Co. Flexible cloth; 6½ × 8¼ ins.; pp. 78; 80 figures in the text. $1.25, net.

ROAD MAKING AND MAINTENANCE.—A Practical Treatise for Engineers, Surveyors, and Others. With an Historical Sketch of Ancient and Modern Practice. By Thomas Aitken, M. Inst. C. E., Surveyor to the County Council of Fife, Cupar Division. Second Edition. London, England: Charles Griffin & Co. Cloth; 6 × 9¼ ins.; pp. 525; 167 illustrations, partly in the text. 21s., net; American price, $8.40.

STRENGTH OF MATERIALS.—A Manual for Students of Engineering. By William Charles Popplewell, Assoc. M. Inst. C. E., Lecturer on Strength of Materials, Theory of Structures, and Hydraulics, at the Manchester Municipal School of Technology. Edinburgh and London: Oliver & Boyd. Cloth; 5½ × 9 ins.; pp. 180; 105 illustrations, mostly in the text. 5s., net; American price, $2, net.

STRUCTURAL DRAWING.—By C. Franklin Edminster, Instructor in Department of Fine and Applied Arts, Pratt Institute, Brooklyn, N. Y. Published by the Author. ("Supplied" by David Williams Co., New York.) Cloth; 8¾ x 7¼ ins.; pp. 148; 74 illustrations, mostly in the text. $2.50.

TESTS OF REINFORCED CONCRETE BEAMS.—Series of 1906. By Arthur N. Talbot. Bulletin No. 14, University of Illinois Agricultural Experiment Station. Urbana, Ill.: The University. Paper; 6 × 9 ins.; pp. 36; 14 illustrations, mostly in the text.

Electrical Engineering.

AN INTRODUCTION TO THE STUDY OF ELECTRICAL ENGINEERING. — By Henry H. Norris, M. E., Professor of Electrical Engineering, Sibley College, Cornell University, M. A. I. E. E., etc. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. v + 404; 179 illustrations. $2.50 net.

EXPERIMENTAL ELECTRICAL ENGINEERING.—And Manual for Electrical Testing. For Engineers and for Students in Engineering Laboratories. By V. Karapetoff. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xxxiv + 790; 538 illustrations. $6, net.

Mathematics.

PLANE AND SPHERICAL TRIGONOMETRY. —By A. M. Buchanan, LL.D., Professor of Mathematics, Cumberland University. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 96; 30 figures in the text. $1, net.

Mechanical Engineering.

HOW TO BURN ILLINOIS COAL WITHOUT SMOKE.—By L. P. Breckenridge. Bulletin No. 15, Engineering Experiment Station, University of Illinois. Urbana, Ill.: The University. Paper; 6 × 9 ins.; pp. 44; 11 illustrations, mostly in the text.

MACHINE DESIGN.—By Albert W. Smith, Director of Sibley College, Cornell University, and Guido H. Marx, Assoc. Prof. Mech. Engg., Leland Stanford, Jr., University. Second Edition, revised and enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. x + 389; 278 illustrations. $3.

PUMPING ENGINES FOR WATER-WORKS. —By Charles Arthur Hague, M. Am. Soc. C. E., M. Am. Soc. M. E. New York: McGraw Publishing Co. Cloth; 6 × 9½ ins; pp. 372; 113 illustrations, partly in the text. $5.

THE GAS ENGINE.—By Frederick Remsen Hutton, Emeritus Professor of Mechanical Engineering in Columbia University. Third Edition, thoroughly revised. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xx + 562; 241 illustrations. $5.

THE GAS ENGINE IN PRINCIPLE AND PRACTICE.—Consisting of Articles Published in "Gas Power" and Other Descriptive Matter and Tables. Written and Compiled by A. H. Goldingham, Mechanical Engineer and Expert, Author of "Oil Engines." St. Joseph, Mich.: Gas Power Publishing Co. Cloth; 6 × 9¼ ins.; pp. 195; 107 illustrations in the text. $1.50.

Mining Engineering.

MINE GASES AND EXPLOSIONS.—A Text-Book for Schools and Colleges and for General Reference. By J. T. Beard, C. E., E. M., Principal of the School of Mines (Coal Mining Division), International Correspondence Schools, etc. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 × 7½ ins.; pp. xvii + 402; 68 illustrations. $3, net.

TECHNICAL METHODS OF ORE ANALYSIS. —By Albert H. Low, formerly Chief Assayer, United States Mint, Denver. Third Edition, revised and enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; pp. xii + 344; $3.

Miscellaneous.

MODERN PIGMENTS AND THEIR VEHICLES.—Their Properties and Uses Considered Mainly from the Practical Side, and How to Make Tints From Them. By Frederick Maire, formerly Editor of "Painting and Decorating." New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 × 7½ ins.; pp. xi + 266; $2.

INDUSTRIAL ENGINEERING

A RECORD OF NEW TOOLS ~ PROCESSES AND APPLIANCES ~

The publication of material in this section is not paid for. While it partakes more or less of the nature of advertising of the firms mentioned, it is intended as review notices of some of the more important catalogues received describing new features in machinery, materials, processes, etc., of interest to the engineering profession.

THE HOME SHOW.

During the week of May 2-9, The Home Exhibits Co., Inc., of 52 Broadway, will hold an exposition, known as the "Home Show," at Grand Central Palace, New York City. The object of this exhibition is to bring together those already owning homes, those who contemplate building them, and those whose business it is to construct, furnish and decorate them.

The time selected for holding the show is strikingly opportune, as it is at this season of the year that those contemplating the erection of a suburban or city home are most interested in viewing the various building materials, heating and lighting apparatus, plumbing supplies, fireplaces, mantels, floorings, wall papers and other wall coverings, etc.; together with the numerous decorative and utilitarian devices, such as chandeliers, electroliers, radiators and furnishings of various kinds, in addition to innumerable labor-saving inventions now obtainable for use in the modern home.

During the past two years more home sites have been purchased in and around New York City than in any like preceding period and the coming seasons promise to inaugurate an era of home building on a magnitude never before witnessed. This and the nature of the exposition—one appealing to the interests of practically every adult member of the ten-million population of the metropolitan district, and not merely to those of special classes, as have most of the successful shows held—have so favorably impressed those engaged in the manufacture and supply of materials, that already a considerable portion of the available space has been taken, and the remainder is being spoken for at a rapid rate.

In addition to the exhibits proper, the management has arranged for a number of special attractions, including a series of concerts to be rendered every afternoon and evening.

NEW METHOD OF DUPLICATING DRAWINGS.

A new process whereby copies can be made of any opaque ink drawing in black lines and upon any kind of paper or cloth, tracing cloth included, has been recently perfected by The Electro-Sun Blue Print Co., of 44 Broad St., New York City. Any defects in the original tracings or drawings will not appear in the copies, and, unless the originals are absolutely defaced, perfect copies can be obtained. If desired, any part of a drawing can be omitted, as well as any changes incorporated. The copies are of the same size as the original, all shrinkage being obviated in the process. Colors other than black can be used, if preferred. The process is an inexpensive one, and those requiring a class of work of superior quality, approaching in excellence that accomplished by lithographic methods, will do well to communicate with the company for additional particulars.

THE PROTECTION OF WOOD PILING AGAINST MARINE WOOD BORERS.

Railway engineers have planned and worked for years to prevent the action of teredo, limnoria and other marine wood borers which destroy the piles of docks, wharves, bridges and trestles in the regions where salt water is to be spanned. These destructive worms, it appears, are found every year farther and farther north. In fact, Barnegat Bay and even Jamaica Bay in Long Island are more and more frequented by these wood destroyers.

It is an interesting fact to note that it is possible for a single mollusk of this type to hatch a billion of its sporadic offspring. At this early stage of the teredo, it is also microscopic and moves about in the water and attacks any woodwork which may have been left

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LOCK JOINT TILE PILE PROTECTION.

exposed, entering it by a hole not larger than a pin head. After they have started their boring they grow, not only in length, but also in diameter, and sometimes have been known to have reached diameters as great as three-fourths of an inch. The teredo is whitish in color, and has two small flexible tubes or siphons continuously extending into the water from the small entrance hole in the wood. It is very important that these vital organs be constantly submerged in comparatively pure salt water, as it is through these organs and from the water that the teredo gets his nourishment. Thus it is that any substance which will permanently cut off the surface of the wood from contact with pure salt water, will not only kill the teredos that are already in a pile, but will prevent the entrance of other teredos. Various methods have been tried with more or less success, such as the driving of thousands of round-headed iron tacks closely together into the pile, copper sheathing, spirally wrapping the pile with tarred burlaps, coating concrete shells around the pile, stringing ordinary sewer pipe over the top of the pile and then filling in with sand, etc., etc.; but all of these are open to objection, on account of expense, corrosion, liability to detachment, inability of the protection to automatically adjust itself to a receding mud line, inconvenience in repairs, etc.

The lock joint pipe, made by the Lock Joint Pipe Company, 346 Broadway, New York, is a system which has been devised for the purpose of obviating these defects, and consists of sections of concrete pipe made in halves so as to be placed around a pile and then filled with sand. The joints are locked and sealed tightly so as to hold the finest sand. Thus it is claimed that the pipe does not adhere to pile but settles gradually and follows the mud line, always keeping the pile protected throughout the field of attacks of the marine wood borers. It is thus impossible for the teredo to enter a pile above this protection and live so long as this protection stands above the high water mark.

This system can be applied to old structures as easily as to new without removing the deck, without interfering with traffic and without the necessity of employing a diver and his expensive outfit. Inspection is a simple matter since sand showing at the top assures sand in place down to the lowest mud line.

It is to be remembered that the life of the teredo depends upon his ability to be continuously in contact with salt water of comparatively pure quality, and the placing of the lock joint pipe around the pile smothers the teredo inasmuch as it cuts off his access to pure salt water.—From literature of the Lock Joint Pipe Co.

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Portion of Pile Destroyed by Teredo.

Life-Size Picture of Teredo.

HEATING AND VENTILATING A LARGE FACTORY PLANT.

It is becoming more and more recognized among engineers that the only practical way of heating a factory, both as regards efficiency and economy, is by some form of the fan system. In this system, the air is blown by means of the fan over heating coils, which usually utilize the exhaust steam of the fan engine, and thence carried through ducts to the various parts of the building. A brief description of this system of heating and ventilating, as recently installed by The Buffalo Forge Company, of Buffalo, N. Y., at the Geo. N. Pierce Co.'s new automobile manufacturing plant, in the same city, may prove not without interest.

This plant, one of the largest and most modern factories in the world, consists of eight buildings, covering about fifteen acres of ground, which are built entirely of reinforced concrete. After considering the matter very carefully, The Buffalo Forge Company's engineers decided that the best method would be to place a separate heating plant in each of the five larger buildings.

A small portion of each of the buildings decided upon was partitioned off and the heating apparatus installed therein. Briefly, each outfit consists of an engine-driven fan, drawing the air from outside through heater coils, which are supplied with either live or exhaust steam. From the fan the air is led through ducts underneath the buildings and up through risers in the various rooms. These tunnels through which the air is led are built of concrete and in some cases measure as much as 6 × 7 ft. in cross-section. In the manufacturing building, which is 400 × 155 ft. and 20 ft. high, and has a total cubic contents of about 1,350,000 cu. ft., the following apparatus was installed: Fan, with blast wheel 113 ins. in diameter by 54½ ins. wide, with ¾-in. steel plate housing, driven by a direct-connected 10 × 10-in. horizontal side-crank engine, at a speed of 175 r.p.m. This fan has a guaranteed capacity of 61,000 cu. ft. per min. The heater for this building alone contains nearly two miles of 1-in. pipe. The stock building, measuring 400 × 35 ft., with an average height of about 20 ft., contains about 280,000 sq. ft. The requirements here, of course, are not so great and a smaller blast wheel, measuring 64 ins. in diameter and 30 ins. wide, driven by a direct 5 × 5-in. vertical engine at a speed of 290 r.p.m., giving the fan a capacity of 17,000 cu. ft. of air per min., are sufficient. The Assembly Building is one of the largest, being 400 × 120 ft., with an average height of 40 ft., and contains about 1,920,000 cu. ft. This is heated and ventilated by a fan with blast wheel 10 ins. in diameter, of the full housing type, driven by a direct-connected 10 × 10-in. engine at a speed of 164 r.p.m. It has a capacity of 68,000 cu. ft. of air per min. In the heater coils in this building were used 9,912 lin. ft. of 1-in. pipe. The apparatus in the other buildings is on a similar large scale, each set being specially designed to suit individual needs for heating and adequate air supply.

All of the above fans are constructed of

heavy steel plate, with forged steel shafts turned to size. The engines used are specially designed for fan driving, and are the standard Buffalo Forge Fan Engines. The heaters are all built on the Buffalo sectional base plan, with steel pipes screwed into cast-iron bases. They are connected so as to be controlled separately, and so that they may be supplied with live steam when sufficient exhaust is not available. They are tested under 180 lbs. water pressure before leaving the factory. The apparatus, as installed, is guaranteed by the manufacturer to heat these buildings to 70° F. when the outside temperature is 10° below zero.

VACUUM PUMPS FOR DIRTY WATER.

"A pump operating on the vacuum principle possesses decided advantages where sand or other gritty material is contained in the water, and the remarkable lightness of weight and ease with which its location can be changed as excavation work shifts or mine shafts are sunk lower and lower, make this type of pump particularly useful in unwatering cofferdams, caissons, mines, quarries and isolated work of all kinds.

"The idea of raising water by the condensation of steam in a chamber and then forcing it up to a still higher level by the direct pressure of steam on the surface of this water in the same chamber, originated with Capt. Thos. Savery, who, in 1698, patented his celebrated 'fire engine.' Properly speaking, his device was not an engine, but a sort of pump, a forerunner of the present Emerson steam pump. In operating Thos. Savery's engine one cylinder was filled with steam, the steam valve was closed by the operator and a spray of water was then injected into the steam. The continual services of a man were needed to operate the steam valve and an almost continuous stream of water was delivered.

"In general, the Emerson pump consists of two long cigar-shaped cylinders or receiving tanks each connected at the bottom through upward opening valves with the suction pipe; and also connected, again with upward openings valves, with the discharge pipe, thus having but four valves in all for the average standard pump.

"In the Emerson pump the steam is used twice. First it presses directly down on the surface of the water in the chamber and forces it out through the discharge pipe. Second, this same steam is itself then suddenly condensed, creating a vacuum which refills that chamber with a new charge of water.

"The mechanism for controlling the admission of steam alternately to the two cylinders, is all encased so as to be entirely protected from any danger of injury or clogging by dirt or other accumulation. The Emerson pump can be operated with perfect success although nine-tenths submerged in water. The admission and cut-off valve is a flat rotary valve turned by a very small engine which is hidden in the upper end of the pump, the exhaust pipe of which empties into the suction pipe of the pump. Thus no steam is liberated and this pump is ideal for underground work where greasy steam in the air would cause discomfort for the workmen.

"A saving of at least 25% in the amount of fuel, one of the main advantages claimed for the Emerson pump, is the result of early steam cut-off, which is made possible by the design of the rotary slide valve steam ports."—From literature of the Emerson Steam Pump Co., Alexandria, Va.

NOTES ON STEEL PILING.

"In the first place it is of the utmost importance that a shape of metal be selected which has the greatest possible strength and stiffness with the minimum weight of metal. When being driven a steel sheet-pile is subject to the conditions of a column loaded at both ends, one end load being the resistance of the ground, the other being the blow of the hammer, and it is at this time particularly that the steel sheet-pile is subject to its most severe duty, and then stiffness is paramount. In fact, the greater the stiffness the easier it will drive, because all the force in the blow of the hammer is usefully employed, while, if the sheet pile has not the required stiffness it will soon buckle in any kind of hard soil, and then most of the force in the blow of the hammer is spent or absorbed in increasing the distortion of the sheet pile and in overcoming the resulting friction between the contiguous sheet-piles. That this feature of stiffness can not be emphasized too strongly has been well proved by numerous failures of steel piling formed of sections weak in this respect, whether these sections are used alone or in connection with very stiff members.

"The next most important requirement of a satisfactory steel sheet-piling is that it shall form a wall or shoring wherein the members act in unison, otherwise there is a mass of superfluous metal which does no work and must

be supported by bracing together with the material, soil or water, which it is supposed to carry. It is far more important to have steel piling sections which lock rigidly together than to have sections which have a limited amount of play, because, as a rule, the steel piling is driven in straight lines and for sharp corners special sections are necessary anyway. Where there is no rigid interlocking, it is almost impossible to drive the individual piles in a straight line and the result is a sheet-piling wall which bears heavily and very unevenly against the wales or bracing required to hold it up.

"In the corrugated system of steel sheet-piling these objections are overcome. The sections used are individually the stiffest possible and they interlock rigidly. There is certainly no form of metal stronger than a corrugated sheet or plate to resist such forces as act first upon the individual sheet piles and then upon the sheet-piling as a whole. A remarkable feature of the corrugated sections is that their stiffness remains practically constant for equal radii of corrugation, irrespective of the thickness of the sheet or plate.

"Corrugated piling is comparatively flexible laterally and may be easily deflected, so that while it can be forced through anything except large boulders, it will readily work its way past them if they are not too large. If, however, it is attempted to force corrugated steel piling through a large boulder it will either absolutely refuse to drive at all further, or, if pounding of the pile-hammer is persisted in, the result will be simply to smash the head of the pile or upset the material at the point. It is quite impossible for a corrugated steel pile to buckle because its stiffness will not allow it and the force of the blow will be spent in deforming the material at the ends, and a corrugated sheet pile abused in this way will not interfere with the driving or pulling of the adjacent members.

"In general, for driving steel piling, a 2500-lb. drop hammer may be used, but a 3000-lb. steam hammer is much better. For lengths greater than 30 feet or for driving in very hard soil, clay or hardpan, heavier hammers may be required. The steam hammer is to be preferred as the blows are more rapid and it is easier to drive the steel piling through obstructions, and the piling is less likely to be injured at the top. For hard driving a cap should be used to protect the head of the pile, and this may consist simply of a flat steel plate and a block of hard wood on top, or it may

DRIVING WEMLINGER CORRUGATED STEEL PILING.

consist of a special hammer base such as furnished by the manufacturers of pile drivers. For driving short lengths or for driving in soft soil, the cap may be dispensed with and the hammer made to strike directly on top of the steel pile. The cost of driving is generally about 25% less than for driving wood. In many cases, of course, wood cannot be used at all."—From literature of the Wemlinger Steel Piling Co., 11 Broadway, New York.

William V. Dee, heretofore Eastern Representative of "The Railway Age," has been appointed General Sales Manager for The G. Drouvé Co., Bridgeport, Conn., makers of the "Anti-Pluvius" Skylight, and the Lovell window-operating device.

The Clipper Manufacturing Co., of New York City, has removed from 401 W. 124th St., to new quarters at 366-368 Gerard Ave.

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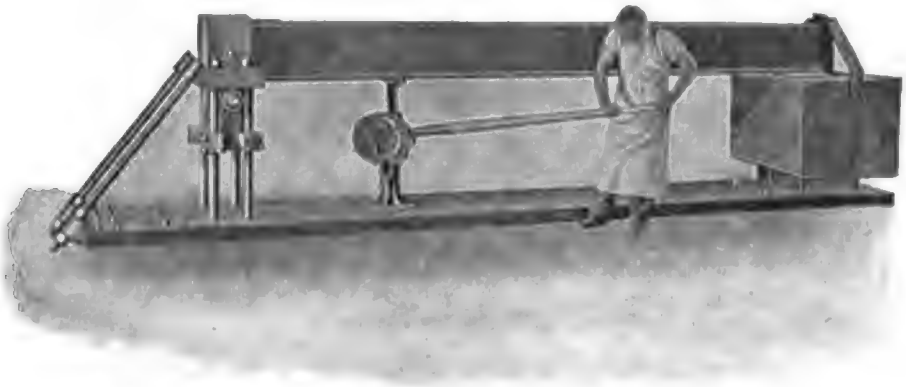
A MACHINE FOR TESTING JACKS.

There has recently been installed by the Joyce-Cridland Co., of Dayton, Ohio, an interesting machine for testing the various kinds of jacks which the company manufactures. The machine consists simply of a 16-foot bar fulcrumed at one end, and weighted at the other with eight 850-pound weights, any or all of which may be used at one time. The bar is made from an ordinary 15-inch I-beam and the machine is set over a concrete foundation 6 ft. deep. The weights remain on a spring platform while at rest, and are picked up by inserting pins through the yoke from each side. Directly over this yoke is a hoist for putting on and removing the weights.



METHOD OF OPERATING MACHINE FOR TESTING JACKS.

The base of the machine consists of two 15-inch channel irons placed side by side and with the flat side up. The head is braced by round steel struts to a cast steel head on the end of the channels. The concrete below the channels is reinforced by twisted steel bars, which are placed to give greatest resistance near the fulcrum, where the strain is greatest.

The vertical rods which hold the fulcrum in place are anchored at the bottom of the concrete, so that the fulcrum withstands any pressure which may be applied by the heaviest jack. The fulcrum, attached to the bar by a steel casting, is a pin which carries knife edges both above and below. When the machine is standing idle, the lower knife edges rest on each side of the centering block. When a jack is put under the beam and pumped up, the upper knife edges rise against steel hard plates in the head. Graduations in tons are marked on the I-beam, commencing with one ton. The beam is graduated for each number of weights, the place for each graduation being determined by accurate calibration. On the bottom side of the beam is a sliding clamp or block with a V-shaped notch. The jack to be tested is set just under this notch, and a round pin is laid on top the jack so that it will enter the notch. This insures correct bearing during the tests. By shifting the point of application of the jack and adjusting the number of weights any desired load may be thrown upon the jack before the weights will rise. A hydraulic or other heavy jack can thus be tested under precisely the same conditions as if it were lifting a locomotive truck, car or any other weight.

The Ransome Concrete Machinery Co., Dunellen, N. J., advises us that the company has discovered a method under which it can furnish its bonding mixture in solid form at a price even cheaper than that of ordinary acid solution, and which carries with it the right to use the process. Five pounds of this material, called "Ransomite," is sufficient, ordinarily, to treat from 1,000 to 1,500 sq. ft.

The plant of the Blanc Stainless Cement Company, located at Allentown, Pa., recently began the manufacture of a cement which is said to be immaculate in color and stronger than Portland cement. The cement was perfected, after years of experimenting and demonstrating, by Mr. J. Maxwell Carrere, who is General Manager and Treasurer of the company.

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The India Rubber and Gutta Percha Insulating Company, of 253 Broadway, New York, has changed its name to Habirshaw Wire Company. For over twenty years this well-known company has manufactured Habirshaw wires, cables and cores under the supervision of Dr. W. M. Habirshaw, and now the name of that gentleman has been made a part of the legal title of the company. The company announces, what will be believed readily enough, that the highest grade of insulation will characterize the output of the concern under the new name as well as under the old one.

TRADE PUBLICATIONS.

LIST OF PARTS.—The Wells Light Manufacturing Co., 44 Washington St., New York City. Paper; 8 × 4 ins.; pp. 8; illustrated.

This pamphlet contains a list of the parts for repairing the company's tanks and burners, and the prices of these parts. The list supersedes all other price lists previously issued.

PUMP DATA.—Bulletins 9, 11-20. The Allentown Rolling Mills, Allentown, Pa. Paper; 9 × 6 ins.; pp., each, 8; illustrated.

These eleven bulletins illustrate and describe various types of electric pumps manufactured by the Allentown Rolling Mills. Each bulletin contains, in addition, tables of the range of operation of the type of pump described, the size motors needed to operate them, the total working lift, etc.

UNIVERSAL PORTLAND CEMENT.—The Universal Portland Cement Co., The Commercial National Bank Building, Chicago. Paper; 9 × 6 ins.; pp. 8.

This pamphlet contains a number of interesting views of various buildings and residences, walls and sidewalks in which the Universal Portland Cement was used. The company has plants both at Pittsburg and at Chicago, and as a result can guarantee quicker shipment to all sections of the country than almost any other manufacturers.

NON-FLUID OILS.—New York & New Jersey Lubricant Co., 14 Church St., New York City. Paper; 3½ × 5½ ins; pp. 8.

The advantages arising from the use of Non-Fluid Oils are dwelt on in this little pamphlet. Non-Fluid Oils are fine mineral oils which have been treated so as to become partially solidified. They are neutral and cannot gum or cause corrosion, and in this respect are greatly superior to greases and fluid oils. They are well suited for automobile use and find extensive application in railroad, mining and other work.

INDUSTRIAL BUILDINGS.—Bulletin No. 22. D. C. Newman Collins, M. Am. Soc. C. E., Consulting Engineer and Architect, New York City. Paper; 5 × 7 ins.; pp. 10; illustrated.

This little folder, together with an article reprinted from the "Engineering Magazine" for September, 1907, accompanying it, describes methods for the design and construction of industrial buildings. A list of many of the largest works designed and constructed under the supervision of the author is included in the pamphlet and is a strong tribute to his ability and reputation as an industrial architect.

THE FULLER-LEHIGH PULVERIZER MILL.—Lehigh Car Wheel & Axle Works, Fullerton, Pa. Paper; 9 × 12 ins.; pp 48; illustrated.

The Fuller-Lehigh Mill is described in this catalog and its usefulness for grinding rock, cement, coal, etc., is made apparent. A number of tests made by various users of the Fuller-Lehigh Mill are quoted and show that 80 to 85% of the material ground will pass through a 200 sieve, a record which it is difficult to surpass. The method of operation is thoroughly described and lists of repair parts are given. The catalog is well illustrated and attractively printed.

THE A. S. CAMERON STEAM PUMP WORKS.—Illustrated Catalog No. 35. The A. S. Cameron Steam Pump Works, foot of East 23d St., New York. Paper; 9 × 6 ins.; pp. 158.

In this catalog the various types of steam pumps manufactured by this company are described in detail, complete lists of repair parts and prices are given. In addition to the information descriptive of the Cameron Pump Works' products, there is also considerable matter under the head of "Useful Information," which will be of value to all users of steam pumps. Many facts regarding steam and water, their properties, etc., are given. In addition there are tables giving the areas of circles, advancing by eighths, the capacity of pumps, ratios of areas for given diameters of steam and water cylinders, heights in feet to which pumps will elevate water, friction loss in pounds pressure per square inch, horizontal and vertical distances reached by jets, wrought iron pipe for steam, gas or water, and metric measures and their English equivalents.

THE REGULATION AND CONTROL OF CONCRETE CONSTRUCTION.—By E. S. Larned. The Association of American Portland Cement Manufacturers, Land Title Building, Philadelphia. Paper; 6 × 9 ins.; pp. 12.

Many failures of concrete structures are due, not to the fact that the cement is of a poor quality and cannot do the work required of it, but to the faulty methods of construction employed and to the inefficiency of the inspectors who are at work. The Association of American Portland Cement Manufacturers has distributed considerable literature regarding cement, and concrete, and proper methods of construction in order to disseminate reliable information regarding the subjects, and thereby lessen such dangers as may be attended on the various types of concrete construction. This bulletin is the sixteenth of the series thus issued and is of decided value to engineers and contractors. It may be obtained from the Association upon application.

AIR COMPRESSOR LUBRICATION.—Joseph Dixon Crucible Co., Jersey City, N. J. Paper; 6 × 9 ins.; pp. 24; illustrated.

This pamphlet begins with a quotation from a prominent engineering journal, which states that "It is an established fact that a compressed air system, that is, the air compressor, receiver and discharge pipes, has within itself the potentiality of destructive explosion if the matter of air-cylinder lubrication is indifferently attended to." Such an explosion is due, primarily, to the volatilization of the lubricant employed. If a lubricating substance whose action is like that of graphite, namely, building up and making smooth, uneven surfaces, and one which, like graphite, cannot be volatilized, is employed, all danger of explosion due to unsuitable oils or the excessive use of good lubricants is avoided. The pamphlet also contains a brief article which deals with the use of graphite for lubricating rock drills.

THE IDEAL REINFORCING FOR SLAB CONSTRUCTION.—Albert Oliver, 1 Madison Ave., New York. Paper; 6 × 3½ ins.; ins.; pp. 158.

In the construction of all reinforced concrete floors and roof slabs the vital point is the proper distribution of a sufficient quantity of the reinforcing material. The materials used for this purpose are numerous. Two important points to be observed are that the steel used for reinforcing the material shall have a high tensile strength and that the bond between it and the concrete shall be continuous. The Clinton Wire Cloth Company, whose welded wire is described in this pamphlet, claims superiority for their product over any other reinforcing offered for sale, chiefly on account of these two points. One point which should be noted is that all the company's material is thoroughly tested before being placed in the structure in which it is to be used.

THE EXPANDED METAL SYSTEM OF STEEL CONCRETE CONSTRUCTION.—The Expanded Metal Engineering Co., 225 Fifth Ave., New York. Paper; 5 × 8 ins.; pp. 176; illustrated.

This handsome booklet, containing as it does an extended discussion of the theory of expanded metal, as well as many illustrations of buildings under the process of construction, details of construction work and tables giving the resisting moments and working loads per square foot for expanded metal and concrete of varying composition, will be of interest to the engineer, architect and contractor. Expanded metal has come into such wide use for reinforcing concrete structures that a thorough presentation of all phases of its use and the stresses to which it may be subjected, such as this booklet contains, will be of value, not only to users of expanded metal, but also to all who are connected with reinforced concrete construction.

THE HAINS CONCRETE MIXER.—The Hains Concrete Mixer Co., Washington, D. C. Paper; 9 × 6 ins.; pp. 36; illustrated.

In order to obtain an ideal concrete it is necessary that the cement, sand and broken stone be so incorporated, that the smaller parts shall fill the voids in the larger, and that every grain of sand and every piece of broken stone be covered with a paste formed of the cement and water. The Hains Concrete Mixer is designed to do this as quickly and as economically as possible. The mixer is thoroughly described and illustrated in the pamphlet, as are many notable engineering works on which the Hains machine was used. The principle on which this mixer is built is that the only effective way to mix concrete in a machine is to rotate the charge and not the machine. The Hains Mixer mixes concrete by forcing the wet sand and stone, or gravel, through the dry cement powder, thereby coating the particles with a film of cement paste, and by means of suitably shaped receptacles, imparts the proper motion of rotation to the entire mass to complete the mix. In other words, by rotating the mass of the ingredients but not the mixer.

THE

TECHNICAL PRESS INDEX

220 BROADWAY, NEW YORK

This Index is intended to cover the field of technical literature in a manner that will make it of the greatest use to the greatest number—that is, it will endeavor to list all the articles and comment of technical value appearing in current periodicals. Its arrangement has been made with the view to its adaptability for a card-index, which engineers, architects and other technical men are gradually coming to consider as an indispensable adjunct of their offices.

Each item gives:

1. Full title and author.
2. Name and date of publication.
3. An estimate of length of article.
4. A short descriptive note regarding the scope of the article—where considered necessary.
5. Price at which we can supply current articles.

The Publishers do not carry copies of any of these articles in stock, but, if desired, will supply copies of the periodical containing the article at the prices mentioned. Any premium asked for out-of-date copies must be added to this price.

The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

In order to comply with the many suggestions and requests of readers who desire to make practical use of this index, it is printed on one side of the sheet only, to permit the clipping of any desired items.

LIST OF PERIODICALS INDEXED

JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

Journal Am. Foundrymen's Assn.
Journal Assoc. Engineering Societies.
Journal Eng. Soc. of Western Pa.
Journal Franklin Institute.
Journal West. Society of Engineers.
Proceedings Am. Soc. C. E.
Proceedings Am. Soc. M. E.
Proceedings Can. Soc. C. E.
Proceedings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
Proceedings Pacific Coast Ry. Club.
Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
Transactions Am. Inst. Electrical Engineers.
Transactions Am. Inst. Mining Engineers.

(*Continued on second page following.*)

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TECHNICAL PERIODICALS

An inch card under this heading costs $2.50 a month

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A Journal of Civil, Mechanical, Mining and Electrical Engineering.

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Published every Thursday by THE ENGINEERING NEWS PUBLISHING CO., 220 Broadway, NEW YORK.

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The Iron Age

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Leader and acknowledged authority in all steam railway matters. Published every Friday; over 2,000 pages a year. Domestic, $4.00; Canada, $5.50; other foreign countries, $6.00; single copies, 10 cents.

THE WILSON COMPANY,
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1529 Williamson Bldg., Cleveland, O.

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Concrete Age.
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Industrial World.
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Iron Trade Review.
Irrigation Age.
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Marine Review.
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Mining World.
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Motor Age.
Motor Boat.
Motor Car.
Motor Traffic.
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Municipal Journal and Engineer.
Paper Trade Journal.
Plumber's Trade Journal.
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Popular Science Monthly.
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Power and Transmission.
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Railroad Gazette.
Railway Age.—See Adv. opposite.
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Railway and Marine World.
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Railway Master Mechanic.
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Ingenieur. (w.) Hague.
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Métallurgie. (w.) Paris.
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Schiffbau. (s-m.) Berlin.
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Technique Sanitaire. (m.) Paris.
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Zeitschrift f. d. Gesamte Turbinenwesen. (w.) Munich.
Zeitschrift d. Oest. Ing. und Arch. Ver. (w.) Vienna.
Zeitschrift d. Ver Deutscher Ing. (w.) Berlin.
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For Steel and Reinforced Concrete Building Construction, Foundations, Masonry, etc., see "Engineering Construction and Materials" under CIVIL ENGINEERING; for Heating and Ventilation, see subdivision similarly entitled under MECHANICAL ENGINEERING; for Electric Lighting, see "Lighting" under ELECTRICAL ENGINEERING; for Elevators, see "Hoisting and Handling Machinery" under MECHANICAL ENGINEERING; for Plumbing and Sanitation, see "Sewerage" under MUNICIPAL ENGINEERING.

AUTOMOBILES AND AERIAL NAVIGATION.

Airship Motors.

Gasoline Motors for Aeronautical Work. Sc Am—Jan. 11, 08. 6 figs. 3300 w. 20c. Describes several of the most recent light-weight motors of French design.

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Denatured Alcohol to Prevent Freezing. Roger B. Whitman. Automobile—Dec. 26, 07. 1 fig. 1100 w. 20c.

Driving System, Positive.

The Positive Driving System for Automobiles. M. C. Krarup. Ir Age—Jan. 2, 08. 4200 w. 20c. Describes the principal causes of automobile accidents and means for reducing their frequency.

Dynamometer for Automobiles.

A Remarkable Dynamometer. El Rev—Jan. 11, 08. 3 figs. 1700 w. 20c. Describes an assemblage of power-absorbing and measuring instruments and a large power chart with automatically-operated pointers.

Fuel Systems.

The Fuel System of Automobiles. Thos. J. Fay. Automobile—Dec. 26, 07. 1 fig. 4000 w. Jan. 2, 08. 6 figs. 4200 w. Each, 20c.

Motor for Heavy Vehicles.

The Thornycroft 30-HP. Engine. Comm Motor—Dec. 26, 07. 6 figs. 900 w. 40c. Describes a substantial English model for heavy-vehicle propulsion.

Rectifier Outfit.

Mercury Arc Rectifier Automobile Garage Outfit. R. E. Russel. Central Station—Dec. 07. 2100 w. 20c.

Speed and Distance Recorders.

Principles of Speed and Distance Recorders. Charles B. Hayward. Automobile—Dec. 19, 07. 18 figs. 3300 w. 20c.

CIVIL ENGINEERING

BRIDGES.

Arches.

A Reinforced Concrete Arch. Howard C. Ford. Jl of Engr—May, 07. 6 figs. 2000 w. 80c. Describes the work of replacing a steel highway bridge by a 70-ft. reinforced concrete arch, together with cost data for the work.

Method and Cost of Constructing a Concrete Ribbed Arch Bridge at Grand Rapids, Mich. Engg-Contr—Jan. 8, 08. 1400 w. 20c. Describes method used on a bridge of seven parabolic arch ribs of 75 ft. clear span and 14 ft. rise.

Steel and Concrete Railway Bridge Over the Guindy River. M. Harel de la Noe. Annales Ponts et Chauss—Nov. 07. 15 figs. 7500 w. $1.80. Describes a three-hinged arch bridge of peculiar construction.

Bascule Bridges.

Double Track Trunnion Bascule Bridge Over Bodine Creek, Staten Island Rapid Transit Railway. Eng News—Jan. 17, 08. 4 figs. 1900 w. 20c. Describes a recently erected counterweighted bascule bridge of the Strauss pattern, with overhead counterweight.

The Ohio St. Bascule Bridge at Buffalo, N. Y. Eng News—Jan. 17, 08. 10 figs. 3,000 w. 20c. Describes a bridge differing in many features from any previous type.

Blackwell's Island Bridge.

Erection of the Manhattan Approach of the Blackwell's Island Bridge. Eng Rec—Dec. 21, 07. 1 fig. 1500 w. 20c.

The Construction of the Queens Approach to the Blackwell's Island Bridge. Eng Rec—Jan. 11, 08. 2 figs. 1800 w. 20c.

The Erection of the Anchor Arms of the Blackwell's Island Bridge. Eng Rec—Dec. 21, 07. 3 figs. 2100 w. 20c.

Hudson Memorial Bridge.

The Design for the Hudson Memorial Bridge, New York City. Eng News—Dec 19, 07. 2700 w. 20c. An editorial in which the feasibility of erection is questioned.

The Engineering Features of the Proposed Hudson Memorial Bridge. Eng Rec—3400 w. 20c. A report to C. M. Ingersoll, chief engineer, Department of Bridges, New York City, by Leon S. Moisseiff, engineer in charge.

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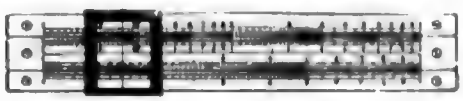

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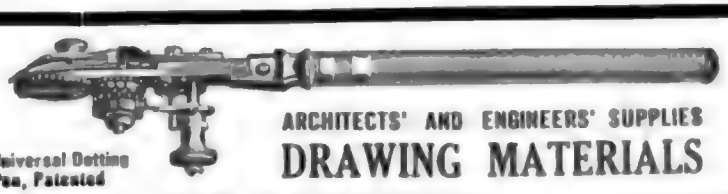

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A Series of Failure Tests of Full-Size Compression Members, Made for the Pennsylvania Lines West of Pittsburg. C. P. Buchanan. Eng News—Dec 26, 07. 53 figs. 6200 w. 20c. Gives results of 19 tests on posts and chords of various sizes.

Twelve Tests of Carbon-Steel and Nickel-Steel Columns. J. A. L. Waddell. Eng News—Jan 17, 08. 3 figs. 4600 w. 20c. Gives results of recent tests on full-size bridge compression members, with a comparison of same and those by Mr. C. P. Buchhanan.

Stresses in Girders.

Determination of Stresses in Web and Stiffeners of Girders: F. E. Turneaure. Ind Mag—Dec., 07. 24 figs. 4400 w. 20c. Presents results of certain experiments on plate-girder webs and stiffeners, together with a theoretical discussion for assisting in interpreting the results.

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The Cost of Steam Shovel Excavation and Dredging at Panama. Eng-Contr—Jan. 8, 08. 3000 w. 20c. From the report of Maj. D. D. Gaillard, of the Isthmian Canal Commission, for first fiscal year ending June 30, 07.

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Building.

A Reinforced Concrete Hotel Building in Oakland, Cal. Edwin L. Soule. Eng Rec—Dec. 21, 07. 6 figs. 1500 w. 20c. Gives details of construction of a 9-story structure.

Chimneys, Reinforced Concrete.

Failures of Reinforced Concrete Chimneys and Recommendations for Design and Construction. Sanford E. Thompson. Eng News—Jan. 9, 08. 2 figs. 5500 w. 20c. Abstract of a report prepared for the Association of American Portland Cement Manufacturers.

Concrete, Handling of.

Handling Concrete in Contractors' Plants. W. F. Tubesing. Conc-Engg—Dec., 07. 1500 w. 20c.

Hoist and Car Plant for Mixing and Placing Concrete for a 30-Span Arch Viaduct. Engg-Contr—Dec. 18, 07. 600 w. 20c.

Dams.

Electrically Operated Sluice Gates for the Shoshone and Pathfinder Dams. F. W. Hanna. Eng News—Jan. 2, 08. 3 figs. 3100 w. 20c. Describes in detail the mechanism and operation of the high-pressure gates used.

Raising a Dam at Lennep, Germany. Eng Rec—Dec. 28, 07. 2 figs. 1400 w. 20c.

The Urft Dam and Hydro-Electric Power Distribution. (Concl.) Engg—Dec. 13, 07. 4300 w. 40c.

Field Work, System in.

System in Contracting—Notes on Field Work. A. D. Williams Jr. Conc Engg—Dec., 07. 1500 w. 20c.

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Diagrams to Determine the Bearing Power of Piles. G. F. Stickney. Eng Rec—Dec. 28, 07. 3 figs. 500 w. 20c.

Reinforced Concrete Construction.

Artistic Treatment of Reinforced Concrete. A. O. Elsner. Mun Engg—Jan., 08. 2500 w. 40c. A paper read before the American Institute of Architects.

Calculations for Reinforced Concrete Construction. C. Viachor. Beton u Eisen—Dec., 07. 3 figs. 3500 w. $1.00. Gives calculations in which the tension of the concrete is considered, and also determinations of the value of E_s/E_c by a number of investigators.

Characteristics of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain. Con & Constr Engg—Jan., 08. 14,000 w. 40c. Gives brief descriptions of details of the leading systems for reinforced beams, floors, columns, etc.

Concrete and Reinforced Concrete Construction in the Rebuilding of San Francisco. John R. Cahill. Con & Constr Engg—Jan., 08. 17 figs. 3800 w. 40c.

Estimating Costs of Forms for Reinforced Concrete. Robert E. Lamb. Conc Engg—Dec., 07. 900 w. 20c.

Experiments with Reinforced Concrete Beams and Columns, Carried Out by Professor Talbot. 1905-1906. Chas. F. Marsh. Con & Constr Engg—Jan., 08. 9 figs. 11,000 w. 40c.

Note on the Calculation of Tension in Reinforced Concrete Beams and the Determination of the Corresponding Reinforcing Bar Diameter. R. Wuckowski. Beton u. Eisen—Dec., 07. 4 figs. 200 w. $1.00.

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Proposed Concrete Construction Code for New York. Conc-Engg—Dec., 07. 1600 w. 20c.

Regulations of the Philadelphia Bureau of Building Inspection in Regard to the Use of Reinforced Concrete. Emile G. Perrot. Proc Engrs Club of Phila—Oct., 07. 8 figs. 6300 w. 80c. Paper read before the Engr's Club.

Reinforced Concrete Beams for Long Spans. F. Gebauer. Beton u. Eisen—Dec., 07. 3 figs. 1200 w. $1.00. Conclusion of article describing the Vierendeel system of construction.

Tests of Bond Between Plain Bars and Concrete. L. R. Viterbo. Eng-Contr—Jan. 1, 07. 1 fig. 1000 w. 20c. Gives results obtained at the testing laboratory of the Washington University, St. Louis.

The Question of Bond. H. F. Porter. Conc Engg—Dec., 07. 1700 w. 20c. A discussion favoring the use of smooth bars.

Retaining Walls.

Notes on Retaining Walls. Arthur Thomas Walmisley. Surv—Jan. 3, 08. 9 figs. 5600 w. 40c. Paper read lately before the Civil and Mechanical Engineers Society.

Retaining Walls on the Delaware, Lackawanna & Western R. R. at Buffalo. Eng Rec—Dec. 21, 07. 1 fig. 1100 w. 20c. Describes recently completed reinforced-concrete retaining walls for track elevation work.

Sewer Construction.

Method and Cost of Driving a Short Tunnel for a Sewer. Eng-Contr—Jan. 1, 07. 5 figs. 2200 w. 20c.

Proposed Traveling Form for Constructing Water Pipe or Sewers. Engg-Contr—Jan. 8, 08. 1 fig. 900 w. 20c.

Structural Steel Vs. Reinforced Concrete.

Structural Steel vs. Reinforced Concrete. R. E. W. Hagarty. Can Cement & Conc Rev—Dec., 07. 2 figs. 2500 w. 20c. From "Applied Science," the journal of the University of Toronto Engineering Society.

Tunnels.

Air Compressors on New York Tunnel Work. Frank Richards. Comp Air—Jan., 08. 10 figs. 4100 w. 20c.

A New Highway Tunnel Under the Thames River at London, England. E. H. Tabor. Eng News—Dec. 19, 07. 17 figs. 4200 w. 20c. Describes the construction of the Rotherhithe tunnel and the shields and excavating machines used for the main and pilot tunnels.

Repairing the Tunnel at Altenbacken. Zeit fur Bauwesen—Nov., 07. 3 figs. 2100 w. $2.00. Describes methods used in repairing a tunnel of the Soest-Kriensen R. R. in the Egge Mountains, Germany.

Water Tank, Reinforced Concrete.

Reinforced-Concrete Water Tank. Max Sieb. Beton u. Eisen—Dec., 07. 11 figs. 5000 w. $1.00. Gives calculations and methods of construction for a large reservoir supported on columns, used in a curtain factory in Plauen, Saxony.

MATERIALS.

Asphalts.

Asphalts—Their Origin, Development and Uses—I. T. Hugh Boorman. Waterproofing—Dec., 07. 6000 w. 20c.

Cement and Concrete.

Concrete of Exposed Selected Aggregates. Albert Moyer. Mun Engg—Jan., 07. 4 figs. 2200 w. 40c.

Hydraulic Properties of Reground Cement Mortars. Engg—Contr—Jan. 1, 08. 1200 w. 20c. Extract from a paper presented at the annual convention of the Assn. of American Portland Cement Mfrs.

Portland Cement in Rocky Mountain Region. George J. Bancroft. Min Sc—Dec. 26, 07. 2 figs. 2700 w. 20c. Discusses the quality and extent of deposits in Colorado, Utah and Wyoming, the grade and price of product, and gives a brief outline of manufacturing process used.

Some Historical Notes on the Invention of Portland Cement. Con & Constr Engg—Jan., 08. 3 figs. 1000 w. 40c.

The Analysis of Concrete. Royal L. Wales. Eng News—Jan. 9, 08. 1800 w. 20c.

The Cement and Hydraulic Limes Industries from the Consumer's Point of View. H. Le Chatelier. Brit Claywkr—6400 w. 40c. Translated from the "Revue Metallurgique."

The Finish of Concrete Surfaces. Eng Rec—Dec. 28, 07. 1400 w. 20c. Gives instructions for imparting a variety of surface textures to concrete work. Extracts from a paper before the Boston Soc. of C. E., by M. C. Tuttle.

The Modern Manufacture of Portland Cement.—II. Brit Claywkr—Dec., 07. 3 figs. 1600 w. 40c.

Iron and Steel.

Breaking Tests of Nicked Bars.—II. Herr Ehrensberger. Z V D I—Dec. 28, 07. 7 figs. 3000 w. 60c. Describes tests on carbon and alloy steels by means of a pendulum hammer testing machine.

Cold-Rolled and Cold-Drawn Steel Bars. Arthur J. Wood. Eng News—Jan. 17, 08. 4 figs. 2200 w. 20c. Gives comparative tests of both kinds of bars, which seem to show that they both possess the same general qualities.

Notes on the Comparative Rusting of Cast and Wrought Iron. A. Schleicher and G. Schultz. Stahl u. Eisen—Jan. 8, '08. 7 figs. 3000 w. 60c.

Torsion Tests on Rectangular Bars. August Hempelmann. Dingler's Poly Jl—Dec. 7, 07. 1 fig. 2400 w. Dec. 14. 7 figs. 1600 w. Dec. 21. 5 figs. 2200 w. Each 40c.

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The Baryta Treatment of Decayed Stone. H. A. Church. Am Arch—Dec. 21, 07. 1300 w. 20c. From "The Stone Trades Journal" for Nov., 07.

The Stone Crushing Plant at the Menard, Ill., Penitentiary. Eng Rec—Dec. 21, 07. 2 figs. 1400 w. 20c.

Wood.

The Strength of Wood. H. D. Tiedman. Wd Craft—Jan., 08. 2400 w. 20c. Abstract of paper read at a meeting of the American Society for Testing Materials. Discusses the effect of moisture, temperature, speed of loading, drying, and other extrinsic factors of wood.

RIVERS, CANALS, HARBORS.

Canals.

The Rhein-Weser Canal. Zeit für Bauwesen—Nov, 07. 13 figs. 17,000 w. $2.00. Describes the proposed canal and treats at length of its effect on transportation in Germany, together with a discussion on the advisability of electrifying the route and methods to be adopted therefor.

The Flushing Tunnel for the Gowanus Canal, in Brooklyn, N. Y. Eng Rec—Jan. 11, 08. 4 figs. 3800 w. 20c.

Dock.

The Steel Ore Dock at Natvok, Norway. John Birkinbine. Ir Age—Jan. 9, 08. 5 figs 2700 w. 20c.

Flow in Pipes, Rivers, etc.

An Investigation of the Flow of Water in Partly Filled Pipes, Canal, Brooks and Rivers. Adolph Staending. Gesund Ing—Dec. 21, 07. 4 figs. 3800 w. 60c.

Flow of Water in Open Conduits. A. P. Merrill. Eng Rec—Dec. 28, 07. 1 fig. 2700 w. 20c. Gives a new formula with coefficients based on the study of a large number of recorded measurements.

Irrigation Pumping Tests.

The Testing of Irrigation Pumping Plants. Eng News—Dec. 19, 07. 3 figs. 5500 w. 20c. Describes methods and apparatus used and results obtained in tests carried out in Cal. under state and governmental auspices.

Land Reclamation.

Land Reclamation in Holland. III. Engr (Lond)—Dec. 13, 07. 2900 w. 40c.

Lock.

Construction and Unit Costs of Concrete Lock, Rough River, Kentucky. Eng News—Jan. 9, 08. 3 figs. 2600 w. 20c.

Rock Cutter for Canal Work.

The Method of Operating a Lobnitz Rock Cutter in Canal and Harbor Work. Lindon Bates. Engg-Contr—Dec. 18, 07. 1 fig. 2000 w. 20c.

Sea Defenses.

A New Sea Wall with Reinforced Concrete Pile Foundation. Zeit für Bauwesen—Nov. 07. 3 figs. 3400 w. $2.00. Describes a recently completed wall at the harbor of Düsseldorf, Germany.

A Simple Mode of Arresting Shore Erosion by Sand Forces. G. C. Sherer. Eng News—Dec. 26, 07. 2 figs. 400 w. 20c.

Reinforced-Concrete Sea Defences.—I. H. Huisman. Con & Constr Engg—Jan., 08. 11 figs. 1900 w. 40c. Describes work in Holland constructed on the Muralt system, which employs expanded metal for reinforcement.

Stream Gaging.

Gaging Water Courses with Shifting Beds. R. Tavernier. Annales Ponts et Chauss—Nov., 07. 18 figs. 1400 w. $1.80. Describes methods used in the Alpine regions, where ordinary methods cannot be employed on account of the continually changing sections of the channel.

SURVEYING, MENSURATION.

Accuracy of Slide Rule Computations. John Berg. Eng Rec—Dec. 21, 07. 1800 w. 20c.

ECONOMICS

Alaska, Engineering Work in.

Natural Conditions Affecting Engineering Work in Alaska. Capt. Geo. B. Pillsbury. Eng News—Dec. 26, 07. 1300 w. 20c.

Apprentices, Education of.

Grand Trunk Apprentice System. Am Engr & R Jl—Jan., 08. 7 figs. 4600 w. 40c. Describes the course used for the past few years, which includes a thorough shop training and a course in mechanical drawing, simple mathematics and applied mechanics.

The Apprenticeship Question. Oscar E. Perrigo. So. Machy—Jan. 08. 3000 w. 20c. Suggests a practical system of instruction to provide for their technical as well as mechanical instruction, to improve the shop conditions under which they work and to increase their interest and enthusiasm in their work.

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The Management of Production in a Great Factory. George F. Stratton. Eng Mag—Jan., 08. 1 fig. 3100 w. 40c. Discusses the division of responsibility and authority in the General Electric Company's shops.

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Taking an Inventory. Sterling H. Bunnell. Eng News—Jan. 2, 08. 2600 w. 20c. Describes a card system for facilitating the work.

Naval Engineers, Education of.

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Electrochemical Analysis with Rotating Anodes in the Industrial Laboratory.—I. Andrew M. Fairlie and Albert J. Bone. Electrochem & Met Indus—Jan., 08. 6 figs. 1800 w. 40c.

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Alternating Current Phenomena

A Plea for the Physical Treatment of Alternating-Current Phenomena. Lamar Lyndon. El Rev—Jan. 11, 08. 1900 w. 20c.

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Alternators.

Notes on the Parallel Operation of Alternators. Waldo V. Lyon. El Wld—Dec. 28, 07. 3 figs. 4600 w. 20c.

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The Separation of Losses in Direct-Current Machines. El Engr—Dec. 13, 07. 1 fig. 600 w. 40c. Gives a simple and reliable method based on one previously brought forward by Prof. Kapp.

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The Reluctance of the Air-Gap in Dynamo Machines. T. F. Wall. Elec Engg (Lond)—Dec. 19, 07. 16 figs. 4300 w. 40c. Paper on the above subject read before the Manchester Local Section of the Institute of Electrical Engineers.

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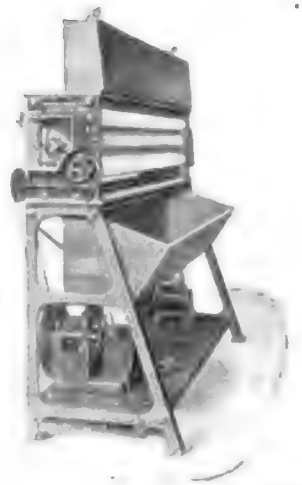

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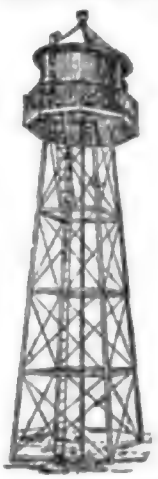

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The Poulsen Wireless Telegraph Station at Cullercoats. Elecn—Dec. 20, 07. 8 figs. 3000 w. 40c. Description of the only Poulsen plant in England.

Wireless Communications Over Sea. J. Erskine-Murray. El Rev—Jan. 1, 08. 3300 w. 20c. Abstract of paper read before the Institution of Engineers and Shipbuilders of Scotland, Dec. 17, 07.

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The Progress of Wireless Telephony in Europe. J. B. Van Brussell. Am Tel Jl—Dec. 21, 07. 2 figs. 1700 w. 20c.

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Electrical Engineering in Great Britain in 1907. W Elecn—Jan. 4, 08. 5 figs. 5800 w. 20c.

Electrical Progress in Europe. C. L. Durand. El Rev—Jan. 11, 08. 3200 w. 20c.

Electrical Progress in the United States in 1907. H. H. Norris. W Elecn—Jan. 4, 08. 12 figs. 6000 w. 20c.

Electrical Progress of 1907 on the Continent. A. de Courcy. W Elecn—Jan. 4, 08. 5 figs. 4700 w. 20c.

The Electrical Industries of 1907. El Rev. —Jan. 11, 08. 3400 w. 20c.

Electricity in Armor Plate Manufacture.

The Use of Electricity in the Manufacture of Armor Plates. J. W. Warr. El Rev—Dec. 27, 07. 3 figs. 2400 w. 40c.

Law, Electric Corporation.

The Law of Electric Companies. John E. Brady. Elec Wld—Jan. 4, 08. 3400 w. 20c. Gives notes on the statutes of electric companies, the laws regarding their regulation and control, etc.

Statistics of Electrical Manufactures for 1907.

Statistics of Electrical Manufactures. W. Elecn—Jan. 4, 08. 1800 w. 20c. Gives estimates of the value of the electrical and auxiliary manufactures in the United States for the year 1907, with corresponding figures for the four preceding years.

Thunder.

The Rolling of Thunder. D. S. Carpenter. Elec Wld—Dec. 21, 07. 8 figs. 1900 w. 20c.

INDUSTRIAL TECHNOLOGY

Brickmaking and Ceramics.

Notes on the Fusibility of Earths Compose of Lime, Silica and Alumina. R. Rieka. Stahl u Eisen—Jan. 1, 08. 1 fig. 2500 w. 60c.

The Effects of Heat on Clay Structure. Brit Claywkr—Dec. 07. 12 figs. 2300 w. 40c.

The Manufacture of Silica Bricks. Brit Claywkr—Dec. 07. 2600 w. 40c.

The Testing of Glazed Clayware. Quarry —Jan. 08. 3000 w. 40c. Paper read by J. W. Cobb before the Yorkshire section of the Society of Chemical Industry.

Explosives, Manufacture of.

The Manufacture of High Explosives. Sc Am—Dec. 28, 07. 3700 w. 20c. Describes the methods used in the Nobel nitro-glycerine works at Aberdeen, Scotland.

Gas Engineering.

Notes on the Construction of Small Gas Plants. Jos Brandt. Jl für Gasbeleuchtung—Nov. 23, 07. 9 figs. 6000 w. 50c. Paper read before meeting of the Association of Gas and Water Supply Engineers of Lower Saxony.

Report of the Committee on Methods of Taking Candle Power of Gas. Am Gas Lt Jl—Dec. 23, 07. 12,000 w. 20c. Read before the American Gas Institute, Washington, Oct. 16, 17 and 18, 07.

Lime Burning.

Gas Kilns. Quarry—Jan. 08. 5 figs. 2500 w. 40c. Describes an improved shaft kiln with generator gas firing for burning lime, dolomite, magnesite, etc.

Nitric Acid.

Nitric Acid From Air. Electrochem & Met Indus—Dec. 07. 7 figs. 3000 w. 20c. Gives a summary of the work of Moscicki and Von Kowalski on the fixation of atmospheric nitrogen by electric discharges.

The Recovery of Nitric Acid. H. Lemaitre. Génie Civil—Dec. 21, 07. 21 figs. 3500 w. 60c. Describes apparatus used in recovering part of the nitric acid used in the manufacture of explosives and other electrochemical industries.

MARINE ENGINEERING

Cable Ship.

A New Cable Ship. Engr (Lond)—Jan. 3, 08. 7 figs. 2000 w. 40c. Describes a new twin-screw cable repairing steamer for use around the west coast of South America.

Heating and Ventilating Ships.

The Heating and Ventilating of Ships. Sydney F. Walker. Inter Mar Engg—Jan. 08. 2 figs. 3000 w. 40c.

"Kronprinzessin Cecilie."

The Hamburg-American Steamer "Kronprinzessin Cecilie." F. C. Guenther. Inter Mar Engg—Jan. 08. 14 figs. 2100 w. 40c.

Stream Lines Around Ships' Models.

An Experimental Investigation of Stream Lines Around Ships' Models. D. W. Taylor. Inter Mar Engg—Jan. 08. 4 figs. 1500 w. 40c. Read before the Society of Naval Architects and Marine Engineers, New York, Nov. 21, 07.

List of Books on

Cement and Plain and Reinforced

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CEMENT AND CONCRETE. By Louis C. Sabin. Second Edition. 583 pages, 161 tables of tests. Price, $5.00.

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PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION. By F. E. Turneaure, Dean of the College of Engineering, University of Wisconsin, and E. R. Maurer, Professor of Mechanics, University of Wisconsin. 8vo, viii + 317 pages, 11 plates and 130 figures. Cloth, $3.00.

REINFORCED CONCRETE. By Walter Loring Webb and W. Herbert Gibson. 150 pp., 140 illustrations. Price, $1.00.

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THEORY OF STEEL-CONCRETE ARCHES AND OF VAULTED STRUCTURES. By William Cain. 215 pages, illustrated. Price, 50 cents.

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CONCRETE FACTORIES. By Robert W. Lesley. 152 pages, numerous illustrations. Price, $1.00.

INSTRUCTIONS TO INSPECTORS ON REINFORCED CONCRETE CONSTRUCTION. By George P. Carver. Price, 50 cents.

CEMENTS, MORTARS AND CONCRETES. By Myron S. Falk, Instructor in Civil Engineering in Columbia University. 184 pages, numerous illustrations. Price, $2.50.

EXPERIMENTAL RESEARCHES UPON THE CONSTITUTION OF HYDRAULIC MORTARS. By H. Le Chatelier. Translated by Joseph L. Mack. 128 pages. Price, $2.00.

PORTLAND CEMENT. Composition, Raw Materials, Manufacture, Testing and Analysis. By Richard K. Meade, B. S. 385 pages, 100 illustrations. Price, $3.50.

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ARTIFICIAL STONE, TERRA COTTA, ETC. Edited by John Block. 92 pages, illustrated. Price, 25 cents.

DIRECTORY OF AMERICAN CEMENT INDUSTRIES, 1906. By Charles C. Brown. 636 pages. Price, $5.00.

HANDBOOK OF COST DATA. By Halbert P. Gillette. Flexible leather 622 pages. Illustrated. Price, $4.00.

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Schulz Water-Tube Boiler with Superheater. D. Dietrich. Schiffbau.—Dec. 2, 07. 3 figs. 3000 w. 60c. Describes proposed arrangement for a turbine-driven cruiser.

Water-Tube Boilers for Battleships. C. Striebel. Z V D I—Jan. 4, 08. 18 figs. 7500 w. 60c. I.—Boilers with large tubes (Niclausse, Belleville, Babcock & Wilcox).

MECHANICAL ENGINEERING

Pneumatic Conveyor.

Pneumatic Conveying of Light Materials. Walter B. Snow. Ind Mag—Dec. 07. 2100 w. 20c.

Tide Power Compressor.

Compressing Air by Tidal Power. William O. Webber. Am Mach—Jan. 9, 08. 3 figs. 1000 w. 20c.

FOUNDING.

Bed Plate.

Method of Molding Large Bed Plate. W. W. McCarter. Fdry—Jan. 08. 7 figs. 1800 w. 20c.

Brass Mixtures.

The Jobbing Brass Foundry.—III. J. F. Buchanan. Fdry—Jan. 08. 1500 w. 20c. Discusses the mixtures utilized in the jobbing shop.

Casting in Metallic Molds.

The Szekely Process of Casting in Metallic Molds. Engg—Jan. 3, 08. 4 figs. 700 w. 40c.

Castings, Design of.

The Design of Complicated Castings. William A. Bole. Ir Age—Dec. 26, 07. 4 figs. 3300 w. 20c. Describes the various points to be kept in mind, such as the process of cooling, etc., in order that patterns may be properly designed.

Charcoal Iron.

Charcoal Iron for the Foundry. Harry B. DePont. Fdry—Jan. 08. 1500 w. 20c. Discusses the chemical and physical properties and gives analyses of various grades.

Compressed Air for Foundry Use.

The Use of Compressed Air in Foundries. Otto S. Schmidt. Stahl u Eisen—Jan. 1, 08. 11 figs. 6500 w. 60c. Describes its use in molding machines, hoisting devices, hand pneumatic tools, etc.

Cores.

Machine Cores for Foundry Use. George H. Wadsworth. Fdry—Jan. 08. 1400 w. 20c. Presented at the December meeting of the Chicago Foundry Foreman's Association.

Engine Cylinders.

The Molding of Corliss Engine Cylinders. Castings—Dec. 07. 2 figs. 1400 w. 20c. Describes methods and devices used by C. & G. Cooper Co., Mt. Vernon, Ohio, for cylinders ranging in size from 12-inch bore up to and over 80-inch.

Foundry Layout.

Design of the Iron Foundry. Oscar E. Perrigo. Fdry—Jan. 08. 4 figs. 2000 w. 20c. Discusses the location and arrangement of various departments, giving a model layout.

Melting Iron.

Melting Iron in the Foundry Cupola. Prof. H. McCormack. Electrochem & Met Indus—Jan. 08. 1900 w. 40c. Gives data on cupola practice.

Steel Castings.

Converter vs. Small Open Hearth. W. M. Carr. Fdry—Jan. 08. 1100 w. 20c. III.—Requirements of the slide blown vessel—basic and acid open-hearth processes.

Steel Castings by McHaffie Process. Fdry—Jan. 08. 6 figs. 1100 w. 20c. Describes a process, which, with the exception of the mixture and the subsequent annealing, is similar to ordinary gray-iron practice.

Weakness in Steel Castings. H. J. McCaslin. Castings—Dec. 07. 9 figs. 2300 w. 20c.

HEATING AND VENTILATION.

Coal Consumption in House Heating.

Coal Consumption in House Heating. Met Wkr—Dec. 21, 07. 1600 w. 20c. Gives communications from Prof. Wm. Kent and Mr. Theo. Weinshank regarding the consumption of coal for an average heating season.

Hot Blast Heating.

Hot Blast Heating. Charles L. Hubbard. Dom Engg—Jan. 4, 08. 3 figs. 1800 w. 20c. XIX.—Air Distribution Ducts.

Radiation, Data for Computing.

Data for a Heating Engineer's Handbook. Gerard W. Stanton. Htg & Vent Mag—Dec. 07. 900 w. 20c. Gives table for figuring radiation by Wolff's Rule.

Steam Heating.

Air Valves for Steam Heating Systems.—IV. W. H. Wakeman. Dom Engg—Jan. 11, 08. 3 figs. 1500 w. 20c.

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The Hydraulic Elevator—XIII and XIV. William Baxter, Jr. Power—Jan. 7, 08. 8 figs. 1300 w. Jan. 14. 6 figs. 1100 w. Each, 20c. Describes the "pulling" type of horizontal elevator, showing the operating principle of the Whittier and the Morse-Williams machines, valve construction, etc.

Cableways.

Cableways. F. T. Rubidge. Colo. Jl of Engg—May 1, 07. 14 figs. 5800 w. 80c. Describes various cableways and gives graphical and mathematical analyses of the stresses in towers and in the cable.

HYDRAULIC POWER PLANTS.

Centrifugal Pumps.

New Pumps and Air Compressors. Prof. F. Freytag. Dingler's Poly Jl—Dec. 14, 07. 6 figs. 2500 w. Dec. 21. 9 figs. 1800 w. Each, 40c. Two articles describing various types of new high pressure centrifugal pumps and giving details of their construction.

Notes on Centrifugal Pumps.—IV. Mech Wld—Dec. 13, 07. 5 figs. 1200 w. 40c. Mathematical exposition of the things involved.

Flow Through Submerged Tubes.

The Flow of Water Through Submerged Tubes: Results of Experiments at the University of Wisconsin. C. B. Stewart. Eng News—Jan. 9, 08. 5 figs. 3300 w. 20c. Abstracts of a forthcoming bulletin on the results of experiments with submerged tubes 4 ft. square.

Hydro-Electric Plants.

Electric Power Plants on Upper Missouri River. A. Floyd Bushnell. Eng & Min Jl—Dec. 28, 07. 3 figs. 1300 w. 20c. Describes a 70,000-volt plant supplied by a steel dam at Hauser Lake, which generates current for Butte, Helena, and Anaconda.

Hydro-Electric Transmission Plant of the Rockingham Power Company. J. S. Viehe. Elec Wld—Dec. 21, 07. 4 figs. 3400 w. 20c. Describes plant on the St. Louis River Yadkin River, 7 miles from Rockingham, N. C.

Power Development on the Chicago Drainage Canal. W. Elecn—Jan. 4, 08. 22 figs. 3400 w. 20c. Describes the hydro-electric power plant at Lockport, Ill., with 4,000-kilowatt generating units and a 44,000-volt aluminum transmission line (about 20½ miles long) to Chicago.

Recent Power Development at Montpelier, Vt. Elec Wld—Jan. 4, 08. 10 figs. 3900 w. 20c.

The Cost of Hydro-Electric Power Development in the Province of Ontario. Eng News—Dec. 19, 07. 4800 w. 20c.

The Water-Power Development of the Great Northern Power Co., Near Duluth. Eng News—Dec. 26, 07. 8 figs. 5600 w. 20c. Describes plant of the St. Louis River designed for an ultimate capacity of 200,000 HP.

Pipe Lines, Calculations for.

Pipe Lines for Hydraulic Power Plants. Eng Rec—Dec. 21, 07. 2 figs. 2800 w. 20c. Gives derivation of a formula for the determination of the most economical diameter for the penstocks of high-head hydraulic power plants.

Pumps.

Modern Pumping and Hydraulic Machinery. Edward Butler. Mech Engr—Dec. 21, 07. 3 figs. 2200 w. Dec. 28. 4 figs. 2500 w. Each, 40c. XXV. and XXVI.—Steam and Air Displacement Pumps.

INTERNAL COMBUSTION ENGINES.

Cylinder Temperatures.

On the Measurement of Temperatures in the Cylinder of a Gas Engine. H. L. Callender. Engg—Dec. 27, 07. 5 figs. 6300 w. 40c. Paper read before the Royal Society, Nov. 7, 07.

Diesel Oil Engine.

Technical Aspects of Oil as Fuel.—IV. F. E. Junge. Power—Jan. 7, 08. 5 figs. 1200 w. 20c. Discusses the economic aspects of the Diesel oil engine, gives comparison between the Diesel and gas engine, and also their comparative fuel costs.

Explosion of Gases.

The Explosion of Gases. John Batey. Cass Mag—Jan. 08. 2900 w. 40c. Discusses the magnitude of the effects produced by combinations of air and fuel with reference to the internal-combustion engine.

Fuels, Data on.

Gas and Oil Engine Diagrams and Fuel Data—I. Peter Eyermann. Power—Jan. 14, 08. 4 figs. 5000 w. 20c. Gives diagrams showing how various fuels act in internal-combustion engines, together with tables giving information on these fuels.

Gas Engines.

Largest Gas Engines for Electrical Work.—I. Cecil P. Poole. Power—Jan. 14, 08. 9 figs. 2000 w. 20c. Gives construction details and operating data of the 4,000-HP. gas engines at the Martin station of San Mateo (Calif) Power Company.

The Gas Engine. Cecil P. Poole. Power—Jan. 14, 08. 17 figs. 14,000 w. 20c. The first of three extended articles on the elementary principles of gas-engine construction and operation.

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The Testing of Gas Producers. Horace Allen. Pract Engr—Dec. 20, 07. 2 figs. 1900 w. 40c.

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Water and Steam Injection.

The Use of Water and Steam in Internal-Combustion Engines. Henry Henderson. Cass Mag—Jan. 08. 5800 w. 40c. Discusses water and steam injection in cylinders for cooling purposes.

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Ball and Roller Bearings.

Ball and Roller Bearings in Practical Operation. Samuel S. Eveland. Proc Engrs Club of Phila—Oct. 07. 31 figs. 8200 w. 80c. Paper read before the Engineers' Club, with brief discussion.

Requisities of Practical Roller Bearings. —I. J. F. Springer. Power—Jan. 14, 08. 7 figs. 1100 w. 20c. Enumerates constructive features which insure serviceability.

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The Bearings of Wood-Working Machines. W. J. Blackmar. Am Mach—Dec. 19, 07. 1400 w. 20c.

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The Variation of the Strength of Gear Teeth with the Velocity. Ralph E. Flanders. Machy—Jan. 08. 2 figs. 2800 w. 40c. Calls attention to the need for more satisfactory values for the stress as affected by the velocity.

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Hydraulic Press Design. Mech Wld—Dec. 27, 07. 7 figs. 1500 w. 40c. Gives formulas used and works out an illustrative example.

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Experiments with Graphite Lubrication. C. H. Benjamin. Am Mach—Dec. 19, 07. 6 figs. 1900 w. 20c. Gives results of tests with deflocculated graphite.

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Design of Rotating Drums. Ulrich Peters. Machy—Jan. 08. 6 figs. 3600 w. 40c. Gives method and formulas for designing rotary kilns and dryers for marls, sand, ore, cement, etc.

Tele-Controller.

New Tele-Mechanic Device. Dr. E. Branly. El Rev—Dec. 2, 07. 6 figs. 1900 w. 20c. Describes improvements in apparatus intended to control different circuits at a distance by means of radio-telegraphy.

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Bending Tests.

Hand Bending Tests. Capt. H. Riall Sankey. Engg—Dec. 20, 07. 9 figs. 2100 w. 40c. Gives results of tests of steel in a hand testing-machine, by means of which the quality of steel can be ascertained from the number of bends required to produce rupture, and from the effort necessary to effect the bending.

Chains, Strength of.

Strength of Chain Links. J. Stieghorst. Schiffbau—Dec. 2, 07. 4 figs. 3500 w. 60c. Gives mathematical analysis of the stresses.

Elastic Limit.

The Elastic Limit and the Testing of Materials. H. Ganssien. Machy—Jan. 08. 6 figs. 2600 w. 40c.

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The Bursting Point of Flanged Fittings. Ir Tr Rev—11 figs. 1500 w. 20c. Gives results of tests made by the Crane Co., Chicago.

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Strength of Rings. Engr (Lond)—Dec. 20, 07. 10 figs. 2000 w. 40c. Gives formulas for determining the strength of rings, with corroborative practical tests.

Testing Machines.

Hydraulic Diaphragm Testing Machines. Engg—Dec. 27, 07. 6 figs. 2400 w. 40c. Discusses their construction, uses and advantages.

Tubes, Collapse of.

The Collapsing Strength of Tubes. E. Preuss. Stahl u Eisen—Dec. 18, 07. 14 figs. 4000 w. 60c. Gives the various formulas proposed, beginning with Fairbairn's and included the recent ones of Carman & Carr and Stewart.

METAL WORKING.

Balancing.

Balancing for High Speeds. Wm. E. Snow. Am Mach—Jan. 2, 08. 9 figs. 600 w. 20c. Describes method for balancing the rotors of steam turbines and high-speed electric generators.

Chain Machine.

Chain-Stud Recessing Machine. Am Mach Jan. 2, 08. 9 figs. 1200 w. 20c. Describes novel machine built by Hans Renold for chain work.

Chuck.

Machining a Chuck Body. G. H. Gibbs. So Machy—Jan. 08. 1 fig. 3200 w. 20c.

Crank-Pin Turning.

A Novel (German) Crank-Pin Turning Machine. Frank C. Perkins. Am Mach—Dec. 10, 07. 1 fig. 500 w. 20c.

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Testing the Cutting Quality of Files. Edward G. Herbert. Am Mach—Dec. 19, 07. 2 figs. 1700 w. 20c. Describes an interesting testing machine and gives results of tests made with ordinary and special steels and correctly shaped teeth.

Gear Cutting.

Gear-Cutting Machinery. Ralph E. Flanders. Machy—Jan. 08. 23 figs. 7600 w. 40c.

High-Speed Steel.

Hardening High-Speed Steels. Nels Gross. Ir Age—Jan. 9, 08. 900 w. 20c.

The Theory of High-Speed Tool Steel. George Auchy. Ir Age—Dec. 26, 07. 7000 w. 20c. Gives conclusions drawn from a comparison of authorities.

Master Plates.

Master Plates and How They Are Made. E. M. King. Am Mach—Dec. 19, 07. 12 figs. 3000 w. 20c.

Milling.

Milling Operations on Vise Parts. John Edgar. Machy—Jan. 08. 10 figs. 1900 w. 40c.

Planer.

Gigantic Metal-Working Planer. Machy—Jan. 08. 13 figs. 3000 w. 40c. Describes the largest tool of its kind ever built, weighing 422 tons and requiring 207 motor HP. to operate.

Tube Straightening.

Tube-Straightening Machines. C. Wades. Stahl u Eisen—Jan. 1, 08. 8 figs. 2000 w. 60c. Describes rolls for straightening gas pipes and boiler tubes.

Turning and Forming Tools.

Formulas for Circular Forming Tools. Machy—Jan. 08. 2 figs. 700 w. 40c.

Machining a Turret-Lathe Turning Tool. A. J. Baker. Am Mach—Jan. 2, 08. 6 figs. 1600 w. 20c. Describes jigs and fixtures that are indexed to set the work at the proper angles while milling and drilling.

Welding by Electricity.

Electric Welding. C. B. Auel. Elec Jl—Jan. 08. 9 figs. 2400 w. 20c. Describes the Benardos arc process, as applied to welding steel castings, pipes and plates.

Worm Wheels, Hobbing.

A Hobbing Machine and Dividing-Head Tests. Am Mach—Jan. 2, 08. 16 figs. 2000 w. 20c. Describes special machine for hobbing accurate worm wheels for dividing heads, the heads being afterwards tested.

REFRIGERATION.

Cold Storage Plant.

The Fish Freezing and Storage Plant of the Consolidated Weir Co., Provincetown. H. S. Knowlton. Eng Rec—Dec. 28, 07. 4 figs. 1400 w. 20c.

Heat Calculations.

Refrigeration. Sydney F. Walker. Mech Wld—Jan. 3, 08. 2300 w. 40c. Ill.—Quantities of heat to be extracted in making ice.

STEAM POWER PLANTS.

Back Pressure, Influence of.

The Influence of Back Pressure and the Receiver Steam on the Steam Consumption of a Reciprocating Engine. C. Eberle, Z V D I—Dec. 21, 07. 24 figs. 7 tables. 8500 w. Dec. 28. 10 figs. 2 tables. 3500 w. Each, 60c.

Boiler and Furnaces.

A Boiler Furnace for Burning High-volatile Coals. Eng Rec—Jan. 11, 08. 2 figs. 2100 w. 20c. Describes a new boiler furnace specially adapted to burning the lignites abundant in the Rocky Mountain region.

A Recent Water-Tube Boiler Test. William Kent. Ind Wld—Dec. 23, 07. 2000 w. 20c. Gives data and results of evaporative tests on an unusually efficient boiler using run-of-mine coal.

Design of Riveted Joints for High-Pressure Boilers. Vernon Smith. Prac Engr—Dec. 13, 07. 8 figs. 1600 w. 40c.

Double Boilers. W. Rottman. Zeit für Dampfkessel und Maschinenbetrieb—Dec. 27, 07. 2 figs. 3000 w. 60c. Gives results of tests of an arrangement of two connected boilers set one above the other, the lower being a flue boiler and the upper either a tubular or flue boiler.

Estimating the Cost of a Return Tube Boiler. F. G. Douglas Wilkes. Boiler Maker—Jan. 08. 4800 w. 20c.

Grille Water-Tube Boilers at the Bordeaux Exhibition. Engg—Dec. 13, 07. 6 figs. 2500 w. 40c. Describes a new type consisting of a cylindrical steam drum to which are riveted a top and a bottom header, connected together by solid-drawn bent steel U-shape tubes.

Methods of Measuring the Entrained Water from Boilers. G. Rosset. Génie Civil—Dec. 21, 07. 1 fig. 3000 w. 60c. Describes densimetric and calorimetic methods.

Some Results Due to Improvement in Boiler and Furnace Design. A. Bement—Elec Ry Rev—Dec. 28, 07. 2 figs. 1300 w. 20c. Abstract of paper presented before the Western Society of Engineers, Chicago, December 18, 07.

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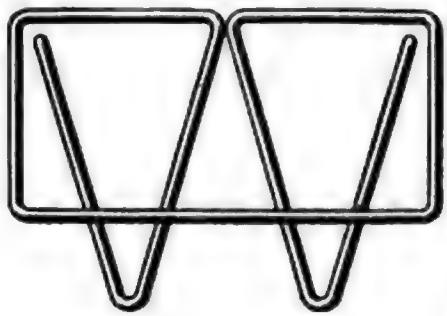

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The Design of Power Plant Chimneys. Frank Kingsley. Eng Rec—Dec. 21, 07. 4 figs. 4500 w. 20c. Discusses the use of Kent's formulas under varying conditions and gives a chart of dimensions of chimneys for different services.

Cooling Towers.

Cooling-Tower Practice. Dr. Jos. H. Hart. Eng Mag—Jan. 08. 15 figs. 2300 w. 40c.

Cost of Power Plants.

Cost of Constructing Steam-Driven Electric Power Plants. Frank Koester. Eng News—Dec. 10, 07. 1900 w. 20c. Gives cost data per KW. capacity of the various elements making up the plant.

CO_2 Recorder.

A New CO_2 Recorder. C. O. Mailloux. Proc Am Inst E E—Jan. 08. 4 figs. 8000 w. 80c. A paper read before the Am. Inst. of E. E., New York, Dec. 13, 07.

Cylinder Condensation.

Cylinder Condensation and Preventives. Engr—Jan. 1, 08. 3 figs. 2400 w. $1.00. Discusses steam jacketing, superheating and compounding.

Engines: Corliss, High Speed, Etc.

American Corliss Engine Practice. Engr—Jan. 6, 08. $1.00. A 30-page profusely illustrated article setting forth the features of the various Corliss designs.

Characteristics of the Corliss Engine. Engr—Jan. 1, 08. 15 figs. 2000 w. $1.00. Describes features of valve gear, single and double eccentrics and gives nomenclature of parts.

Lining Up a Horizontal Engine. T. E. O'Donnell. Engr—Jan. 1, 08. 5 figs. 3200 w. (Special issue.) $1.00. Gives simple and complete directions for this work.

Low and Medium Speed Engines. Engr—Jan. 1, 08. $1.00. A 25-page article, profusely illustrated, describing a large number of two, three and four-valve engines, ranging in speed from 125 to 200 r.p.m.

Tandem Compound Engine with Bollinckx Valve Gear. Engg—Dec. 20, 07. 13 figs. 800 w. 40c. Gives plates showing the arrangements of the valves and valve-gear.

The High-Speed Engine. Engr—Jan. 1, 08. $1.00. A 28-page article describing many piston and slide-valve types and their variations.

Feed-Water.

Simple Methods of Testing Feed-Water and Lubricants. James E. Noble. Power—Jan. 14, 08. 1 fig. 1400 w. 20c.

The Purification of Feed-Water. Charles L. Hubbard. El Rev—Jan. 4, 08. 1 fig. 2400 w. 20c.

Foundations for Engines.

Foundations for the Steam Engine. Engr—Jan. 1, 08. 6 figs. 3000 w. (Special issue, $1.00.) Discusses the materials used and requirements for a good foundation.

Fuels.

Pulverized Coal and Its Industrial Applications. William D. Ennis. Eng Mag—Jan. 08. 11 figs. 3000 w. 40c. II.—Modes of Firing and Construction of the Furnace.

The Jahns System of Transforming Solid Fuel Into Gas. Oskar Nagel. Electrochem & Met Indus—Jan. 08. 5 figs. 1300 w. 40c.

Governors.

Governing the Steam Engine. Engr—Jan. 1, 08. 12 figs. 4000 w. $1.00. Describes a number of typical governors, their action and adjustments.

Heat.

Heat Calculations.—Continued. Chem Engr—Dec. 07. 1 fig. 4000 w. 20c. Gives methods of determining specific heat, thermal capacity, theoretical temperature of combustion.

The Practical Significance of the Carnot Cycle. Joseph H. Hart. Cass Mag—Jan. 08. 3400 w. 40c.

Steam Piping.

Steam Pipe Systems for Generating Stations. John H. Rider. Elec Engg—Dec. 19, 07. 5 figs. 4100 w. 40c.

Steam Turbines.

An Exhaust Steam Turbine Plant. H. H. Wait. Proc Am Inst E E—Jan. 08. 15 figs. 10,000 w. 80c. Describes a turbine utilizing the exhaust steam from a reversible engine which drives the blooming rolls. A paper read before the Am. Inst. of E. E., Dec. 13, 07.

Modern Steam Turbine Practice. Engr—Jan. 1, 08. 4 figs. 1200 w. $1.00. Describes the theory of operation and the construction of the various types made in the U. S.

The Practical Proportioning of the Reaction Steam-Turbine. Engg—Dec. 13, 07. 1 fig. 3700 w. 40c.

The Willans-Parsons Steam Turbine. Engg—Jan. 3, 08. 38 figs. 5600 w. 40c. Gives details of construction of the reaction turbines made by Willans & Robinson, Ltd., Rugby, England.

Tanks, Design of.

Mild-Steel Tank Practice. Mech Wld—Dec. 20, 07. 8 figs. 1800 w. 40c. Gives practical methods for designing tanks for storage purposes.

Valve Setting.

The Indicator for Valve Setting. Engr—Jan. 1, 08. 13 figs. 2100 w. (Special issue, $1.00.)

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Coke-Drawing Machines. Walter W. Macfarren. Ir Tr Rev—Dec. 19, 07. 9 figs. 600 w. Dec 26. 6 figs. 1700 w. Each, 20c. Describes these and other machines for use at the ovens in the manufacture of coke.

The Marmas Coke-Drawing and Loading Machine. Ir Age—Dec. 26, 07. 6 figs. 2200 w. 20c.

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Blast Pipes.

Preventing Blast Pipes from Vibrating. Thomas Evans. Engg & Min Jl—Dec. 21, 07. 2 figs. 400 w. 20c.

Concentrator.

The Six-Thousand-Ton Concentrator of the Utah Copper Co. R. L. Herrick. Mines & Min—Jan. 08. 7 figs. 4400 w. 40c. Describes the machinery equipment and method of milling at Garfield, Utah.

Electric Smelting.

Metallurgical Calculations. J. W. Richards. Electrochem & Met Indus—Dec. 07. 1800 w. 40c. Works out a problem in the electric smelting of copper ores.

Electro Deposition.

Electro Deposition of Copper. A. Humboldt Sexton. Mech Engr—Jan. 4, 07. 1 fig. 5000 w. 40c. Describes the electrolytic refining and electric smelting of copper ores by various processes.

Metallurgy.

The Metallurgy of Copper in 1907. Walter R. Ingalls. Eng & Min Jl—Jan. 4, 08. 1100 w. 20c.

Precipitation by Wet Processes.

Precipitation of Copper From Cupriferous Waters. Frank H. Probert. Min & Sc Press.—Jan. 4, 08. 2 figs. 3200 w. 20c. Gives methods of extracting copper from lean ores by wet processes, at Rio Tinto, Spain.

Smelter.

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The Duplex Process for Steel Making. Prof. Henry M. Howe. Electrochem & Met Indus—Jan. 08. 1100 w. 40c.

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Novel Electric Drive for Rolling Mills. Am Mach—Jan. 9, 08. 3 figs. 1800 w. 20c. Describes method in which a small motor drives the rolls during the passes by utilizing the stored energy of a heavy fly-wheel.

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Iron and Steel Production in 1907. Frederick Hobart. Eng & Min Jl—Jan. 4, 08. 5000 w. 20c.

Solidification of Alloys.

A Graphical Representation of the Solidification of Eutectic Alloys. Electrochem & Met Indus—Jan. 08. 1 fig. 1000 w. 40c.

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The Grey Structural Mill at South Bethlehem. Ir Age—Jan. 2, 08. 12 figs. 2600 w. 20c. Describes some important improvements it possesses over its German prototype.

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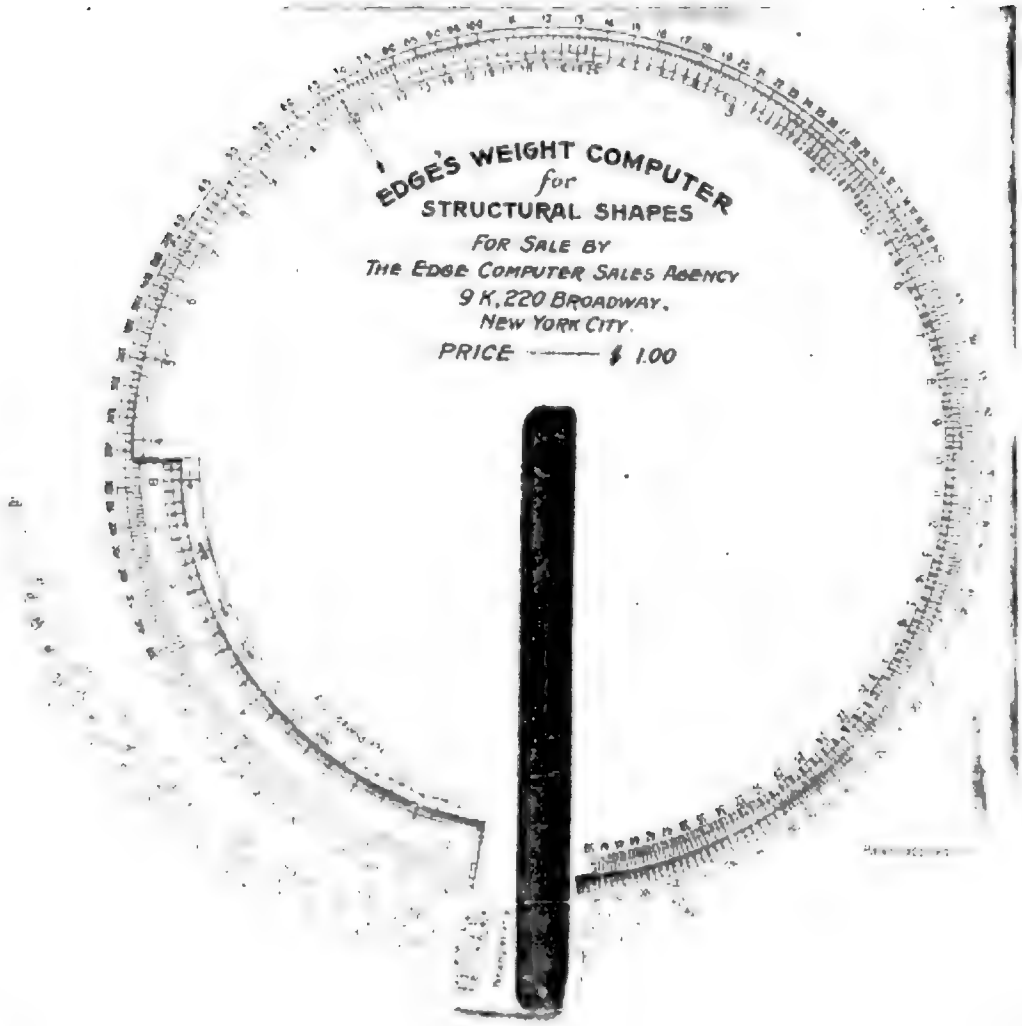

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The Metallurgy of Lead.—I. J. W. Richards. Electrochem & Met Indus—Jan. 08. 4100 w. 40c.

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Modern Milling Practice in Missouri-Kansas Field. Otto Ruhl. Min Sc—Dec. 26, 07. 2 figs. 3200 w. 20c. Discusses improved jigging methods and the increased saving of fines in table concentration.

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Outline for Report on Ore Dressing Plant by the Faculty of the Colorado School of Mines. Min & Min (Denver)—Dec. 27, 07. 700 w. 20c.

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Coal Mine Accidents; Their Causes and Prevention. Clarence Hall and Walter O. Snelling. Min Wld—Dec. 28, 07. 3900 w. 20c. Extract from Bulletin No. 333 (1907) U. S. Geol. Survey.

Monongah Mine Disaster. H. H. Stoek. Mines & Min—Jan., 08. 5 figs. 3000 w. 40c. Describes the methods of working in mines and the conditions before and after the explosion.—The possible causes.

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Electrical Machinery Used in Coal and Coke Operations. W. B. Spellmire. West Elecn—Dec 21, 07. 1 fig. 600 w. 20c.

The Coal-Handling Apparatus of a Large Coke Oven Plant. Eng Rec—Dec. 28, 07. 5 figs. 3300 w. 20c. Describes the handling plant of the By-Products Coke Corporation at Solvay, Ill., about 2½ miles from South Chicago.

Coal Mining.

Electric Power in Coal Mining. Cass Mag—Jan., 08. 23 figs. 3600 w. 40c. Describes the various applications of electric motors in mining work.

Mining Anthracite Coal in the Wyoming Valley. M. S. Hachita. Engg & Min Jl—Dec. 21, 07. 6 figs. 1400 w. 20c. Describes mine in which steel beams are used to support the roof.

The Anthracite Mines at Alden, Penn. M. S. Hachita. Eng & Min Jl—Dec. 28, 07. 3 figs. 2300 w. 20c. Gives data on the haulage cost of coal per ton-mile, average output per miner and methods of subduing a mine fire.

The Diamondville Coalfield, Wyoming. A. T. Shurick. Eng & Min Jl—Jan. 11, 08. 1 fig. 2700 w. 20c.

Compressed Air in Mining.

Applications of Compressed Air to Mining. Jos. H. Hart. Min Wld—Dec. 21, 07. 1800 w. 20c.

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Mining in the Rossland District, British Columbia. Ralph Stokes. Min Wld—Dec. 21, 07. 1 fig. 1600 w. Dec. 28. 2 figs. 2900 w. Each 20c.

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Periodicals, Technical:

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Engineering News, New York.
Engineering Record, New York.
Industrial Magazine, Park Row Bldg., New York.
Iron Age, New York.
Progressive Age, New York.
Railway Age, Chicago.

Phonographs:

Duplex Phonograph Co., 303 Patterson St., Kalamazoo, Mich.

Piling, Steel:

Wemlinger Steel Piling Co., Bowling Green Offices, N. Y.

Pumps:

Rife Hydraulic Ram Co., R., 2100 Trinity B., New York.

Punches, Hydraulic:

Richard Dudgeon, 26 Columbia St., New York.

Railway Supplies:

American Ry. Supply Co., 24 Park Pl., New York.

Schools and Colleges:

Armour Institute of Technology, Chicago.
Clarkson School of Technology, Potsdam, N. Y.
Lehigh University, South Bethlehem, Pa.
Ohio Northern University, Ada, Ohio.
Rensselaer Polytechnic Institute, Troy, N. Y.
Rose Polytechnic Institute, Terre Haute, Ind.

Signal Wire:

Habirshaw Wire Co., 253 Broadway, New York.

Steel Piling:

Wemlinger Steel Piling Co., Bowling Green Offices, N. Y.

Structural Steel Computer:

Edge Computer Sales Agency, 220 Broadway, New York.

Talking Machines:

Duplex Phonograph Co., 303 Patterson St., Kalamazoo, Mich.

Tanks, Wooden:

Baltimore Cooperage Co., Baltimore, Md.

Testing Laboratories:

Industrial Laboratories, 164 Front St., New York.
Meade Testing Laboratory, Nazareth, Pa.
Michigan Technical Laboratory, Detroit, Mich.
Monadnock Laboratories, Chicago, Ill.

Time Checks:

American Ry. Supply Co., 24 Park Pl., New York.

Tool Steel:

Wm. Jessop & Sons, 91 John St., N. Y.

Towers, Steel:

Baltimore Cooperage Co., Baltimore, Md.

Tracing Cloth:

L. & C. Hardtmuth, New York.
Technical Supply Co., 46 East 14th St., New York.

Tube Expanders:

Richard Dudgeon, 26 Columbia St., New York.

Vanadium:

Vanadium Alloys Co., 25 Broad St., New York.

Water Supply:

Rife Hydraulic Ram Co., R., 2100 Trinity B., New York.

Wire, Insulated:

Habirshaw Wire Co., 253 Broadway, New York.

Diamond Mining.

Diamond Mining in South Africa. Wm. Taylor. Min & Min—Jan., 08. 6 figs. 2200 w. 40c. Discusses the geological formations, diamondiferous pipes and methods of removing the "blue ground."

Exploration Work.

Some Experiences with Exploration Tunnels. Arthur Lake. Min Sc—Jan. 2, 08. 3 figs. 3800 w. 20c. States reasons why exploration work should be by sinking cross-cutting, rather than by cross-cutting at depth and raising.

Explosives.

Explosives in Coal Mines. E. J. Deason. Mines & Min—Jan., 08. 6 figs. 6300 w. 40c. A review of the regulations and Woolwich tests, together with methods and apparatus used for testing.

Gas and Oil.

Prospecting for Oil and Gas. Erasmus Haworth. Min Wld—Jan. 4, 08. 1600 w. 20c. Abstract of paper read before Am. Mining Congress, Joplin meeting.

Relation of Anticlinal Structures to Gas, Oil and Water. Arthur Lake. Min Sc—Dec. 19, 07. 2 figs. 1000 w. 20c. Describes conditions in the front range of Colorado, Rio San Juan in Utah and Big Horn Basin in Wyoming.

Gold.

Notes on Churn-Drill Placer Prospecting. J. P. Hutchins. Eng & Min Jl—Dec. 28, 07. 6 figs. 3600 w. 20c. Discusses methods of handling core material, recording results, care of tools and equipment and variations in procedure.

Testing Placer Ground with the Keystone Drill. John P. Hutchins. Eng & Min Jl—Dec. 21, 07. 10 figs. 4200 w. 20c. Describes methods and difficulties of driving pipe, drilling and pumping so as to secure a representative sample.

The Great Gold Mines. T. A. Rickard. Min & Sc Pr—Jan. 4, 08. 2 figs. 3500 w. 20c. First article of a serial giving data and statistics regarding the most productive districts.

The Waihi Gold Mine in New Zealand. Ralph Stokes. Min Wld—Jan. 11, 08. 2 figs. 2700 w. 20c.

Hoisting and Haulage.

Electrical Equipment at the Clausthal Mines. Elec Engr—Dec. 26, 07. 5 figs. 1600 w. 40c.

Electric Hoisting at Grangesberg, Sweden. J. B. Van Brussell. Eng & Min Jl—Dec. 21, 07. 4 figs. 1300 w. 20c. Describes the balanced skips used, which are hoisted by spiral drums, electrically driven and controlled by one lever and raise 1200 tons in eight hours.

Labor-Saving Appliances at the Mines of the New Kleinfontein Company, Transvaal. Engr (Lond.)—Dec. 13, 07. 4 figs. 4700 w. 40c. Describes the conveyor system used for ashes, waste rock and residue sands.

Underground Haulage. Can Min Jl—Dec. 15, 07. 13 figs. 5800 w. 20c. Paper read before the British Society of Mining Students.

Mexico.

The Mineral Resources of Sonora, Mexico. F. J. H. Merrill. Min & Sc Pr—Jan. 4, 08. 9000 w. 20c.

Mine Timbers.

Prolonging the Life of Mine Timbers. John W. Nelson. Min & Sc Pr—Dec. 28, 07. 8 figs. 2600 w. 20c. Abstract from Circular 717, Forest Service, U. S. Department of Agriculture, describing methods used and experiments made.

Mining Costs.

Variations in Mining Costs. J. R. Finlay. Min & Sc Pr—Jan. 4, 08. 3800 w. 20c. Gives and discusses tables of comparative costs of mining gold, lead and copper in the leading districts.

Mining Methods.

Method of Mining Iron Ore in Wyoming. B. W. Vallat. Min Wld—Dec. 28, 07. 2 figs. 1700 w. 20c. Abstract of paper read before the Colo. Sci. Soc., Oct. 5, 07.

Methods of Mining and Handling Ore in Butte. Edward Higgins. Eng & Min Jl—Jan. 11, 08. 3 figs. 1800 w. 20c.

Mining Statistics, 1907.

Mineral and Metal Production in 1907. Eng & Min Jl—Jan. 4, 08. 1000 w. 20c. Gives statistics of the output of the more important substances.

Quarrying.

A Modern Quarry Plant. Engr (Lond.)—Dec. 13, 07. 9 figs. 2000 w. 40c. Describes the equipment of an up-to-date English quarry.

Granite Quarrying. T. Nelson Dale. Min Wld—Dec. 28, 07. 1300 w. 20c. Extract from Bulletin No. 313 (1907) U. S. Geol. Survey, describing the solution of numerous problems met with in such work.

Hydraulic Sluicing Plant. J. A. Yeatman. Jl of Elec Pow & Gas—Jan. 4, 08. 4 figs. 1400 w. 20c. Describes an original and unique California plant for removing the soil over burden in opening a rock quarry.

Silica Sand.

The Silica Sand Industry. Beverley S. Randolph. Eng & Min Jl—Dec. 28, 07. 6 figs. 1400 w. 20c.

Silver-Lead.

Mines of Tintic District, Utah. Robert B. Brinsmade. Mines & Min—Jan., 08. 6 figs. 6000 w. 40c. Describes the regions and methods employed in the principal mines and mills.

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Present View of Genesis of Leadville Limestone Ores. S. F. Emmons. Eng & Min Jl—Jan. 11, 08. 2600 w 20c. From Bulletin 320, U. S. Geol. Survey.

Stoping.

The Method of Breast Stoping at Cripple Creek. G. E. Wolcott. Eng & Min Jl—Jan. 11, 08. 4 figs. 1600 w. 20c.

MUNICIPAL ENGINEERING

REFUSE DESTRUCTION.

A Study of Refuse Disposal. J. T. Fetherston. Eng Rec—Dec. 28, 07. 2900 W. 20c. From a paper read before the Am. Soc. C. E. Dec. 18, 07.

Report on Garbage and Refuse Disposal, Milwaukee, Wis. Engg News—Jan. 17, 08. 4300 w. 20c. Resume of report of Mr. Rudolph Hering on the best means of handling garbage and refuse in that city, giving data and estimates.

ROADS.

Asphalt Repair Plant.

The Municipal Asphalt Pavement Repair-Plant at New Orleans. Eng News—Jan. 2, 08. 2100 w. 20c.

Automobiles and Roads.

Automobiles and Roads. M. Salle. Annales Points et Chauss—Nov. 07. 2 figs. 10,000 w. $1.80. Discusses the destructive effects of automobiles running at high speeds.

Pavement Guarantees.

Pavement Guarantees, Their Use and Abuse. J. W. Howard. Mun Engg—Jan. 08. 1600 w. A paper read before the Board of Trade, Newark, N. J.

Woods for Paving.

Test of Woods for Street Paving. Mun Engg—Jan. 08. 2 figs. 1300 w. 40c. From the last annual report of the city engineer of Minneapolis, Minn.

SANITATION.

Ozone, Use of.

The Noxious Effect of Bad Air in Living Rooms and the Advantages Derived from the Use of Ozone. A. Labbert. Gesund. Ing—Dec. 7, 07. 6000 w. 60c.

Sulphur Dioxide in City Air.

The Contamination of the Air of Our Cities with Sulphur Dioxide. Theodore W. Schaffer. Htg & Vent Mag—Dec. 07. 2100 w. 20c.

SEWERAGE.

Lawrence Experiment Station's Work.

Lawrence Experiment Station. Mun Jl & Engr—Jan. 15, 08. 3 figs. 2200 w. 20c. Gives a brief review of the work done by Massachusetts State Board of Health during twenty years past, together with a statement of the investigations now under way.

Plumbing.

Plumbing, Healthy and Diseased.—II. Henry R. Davis. Met Wkr—Dec. 21, 07. 2700 w. 20c. Paper read before the Homeopathic Medical Society of Washington, D. C., Nov. 5.

The Sanitary Sewerage of Buildings. Thomas S. Ainge. Dom Engg—Dec. 21, 07. 1400 w. 20c. VIII.—Final Test and Inspection of Work.

WATER SUPPLY.

Artesian Well Pumping.

Artesian Well Pumping by Compressed Air. H. Tipper. Eng. News—Jan. 17, 08. 1700 w. 20c.

Best Pipe Diameters for Supply System.

Calculation of the Best Pipe Diameters for Pressure and Gravity Water Supply System. I. Pelinke. Zeit u Oest Ing u Arch—Dec. 20, 07. 2 figs. 6000 w. 60c.

European Water Supplies.

Municipal Work in Frankfort-on-Main. Surv—Dec. 27, 07. 4500 w. 40c. Discusses the water supply and the sewage settling tanks.

Notes on the Water Supplies of Paris and Suburbs. Easton Devonshire. Surv—Dec. 27, 07. 5 figs. 4200 w. 40c. Paper read at the winter meeting of the Assn. of Water Engineers.

Laying Water Mains.

Laying Gas and Water Mains in Streets. M. Melhop. Jl für Gasbeleuchtung—Dec. 14, 07. 1 fig. 2000 w. 50c. Describes convenient methods of laying mains in paved streets.

Stream Flow Measurement.

Field Methods of Measuring Stream Flow. Water—Dec. 16, 07. 3 figs. 2400 w. 40c.

Water Charges and Waste.

Water Charges and Water Waste at Somerville, Mass. Mun Engg—Jan. 08. 2 figs. 1000 w. 20c.

MISCELLANEOUS.

Conduit System.

Municipal Conduit System of the City of Baltimore, Md. Elec Wld—Jan. 4, 08. 15 figs. 3100 w. 20c.

Construction and Repairs in Chicago.

The Construction and Repair Division of the City of Chicago. William D. Barber. Eng News—Dec. 5, 07. 4100 w. 20c.

Public Baths.

Public Turkish Baths. W. Guinow. Gesund Ing—Dec. 21, 07. 3 figs. 3600 w. 50c. Gives various designs for public Turkish bath houses and discusses the advantages of each.

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RAILROAD ENGINEERING

CONSTRUCTION.

Africa.

Railway Progress in the Dark Continent. J. Hartley Knight. Eng Mag—Jan. 08. 17 figs. 2800 w. 40c. Gives a current summary of African railway construction.

New Construction in 1907.

Statistics of Railway Building in 1907. Ry Age—Dec. 27, 07. 7000 w. 20c.

MANAGEMENT AND OPERATION.

Cars and Locomotives Ordered in 1907.

Statistics of Cars and Locomotives Ordered in 1907. Ry Age—Dec. 27, 07. 10,000 w. 20c.

Collisions, Prevention of.

Can Railroad Collisions Be Reduced to a Theoretical Minimum? Harold V. Coes. Eng Mag—Jan. 08. .3 figs. 3800 w. 40c.

Massachusetts Ry. Commission Report.

Report of Massachusetts Railroad Commission. St Ry Jl—Jan. 11, 08. 3600 w. 20c. Abstract of report for the year ending June 30, 07, giving the gross assets, liabilities, capital stock, earnings, etc.

POWER AND EQUIPMENT.

Cars.

Repairing Steel Freight Cars. Am Engr & R R Jl—Jan. 08. 18 figs. 3100 w. 40c. Describes methods used by the Pittsburg & Lake Erie Railroad, in the McKees Rocks shops.

Steel Passenger Equipment. Charles E. Barba and Marvin Singer. Am Engr & R R Jl—Jan. 08. 5 figs. 4400 w. 40c. II.—Gives graphical and algebraic analyses of the stresses in underframes.

The Advantages of Solid Forged and Rolled Car Wheels. Ry Age—Dec. 20, 07. 1 fig. 2300 w. 20c. A chapter from "The Car Wheel" by George L. Fowler, published by the Schoen Steel Wheel Company.

The Draft Gear. Ry & Engg Rev—Jan. 4, 08. 3100 w. 20c. From a paper by A. Stucki before the December meeting of the Pittsburg Railroad Club.

Ventilating and Heating of Coaches and Sleeping Cars. Ry & Engg Rev—Dec. 28, 07. 21,000 w. 20c. Extracts from a paper by S. G. Thompson, read before December meeting of Western Railway Club.

Locomotives.

Handling Locomotive Supplies. E. Fish Ensle. Am Engr & R R Jl—Jan., 08. 11 figs. 6700 w. 40c. Describes the main features and considerations in connection with the practical care, upkeep, supervision, and economy in the handling of engine equipments, based on extended experience and covering the practice of a number of roads.

Walschaert Valve Gear. Am Engr & R R Jl—Jan. 08. 10 figs. 2100 w. 40c. Gives detail drawing of the various parts as used by the Canadian Pacific Railway on their newest locomotives.

Motor Cars.

Steam Motor Cars on the Intercolonial Railway, Canada. Eng News—Dec 19, 07. 4 figs. 1800 w. 20c. Describes experiments on the Ganz geared and on ordinary direct-connected cars.

Pumps for Railroad Service.

Large Pumps for Railroad Service. C. Guillery. Org für die Fortschr des Eisenbahn—Dec. 07. 14 figs. 3000 w. $1.00. Describes various types of large pumps used on German roads.

Shops.

Arrangement of Railroad Shops. George A. Damon. Ry Age—Jan. 10, 08. 2 figs. 2300 w. 20c. Abstract of a paper presented before the Canadian Railroad Club at Montreal, Jan. 7, 08.

Structural Features of the Warwick Shops of the Lehigh & Hudson River Ry. Eng Rec—Jan. 11, 08. 5 figs. 2700 w. 20c.

Signaling.

Automatic Cab-Signaling on Locomotives. J. Pigg. Elec Engr. Dec. 12, 07. 13 figs. 5600 w. Dec 20. 5 figs. 3100 w. Each 40c. Paper read before the Institution of Electrical Engineers.

Station Design.

The Design of Wayside Stations for Single-Line Railways. G. Royal Dawson. Eng Rec—Dec. 28, 07. 10 figs. 4800 w. 20c.

Track.

Notes on Track and Track Construction in the United States. Ch. Juillien. Revue Gen des Chemins de Fer—Dec. 07. 34 figs. 11,000 w. $1.20.

Train Movement Control.

Electro-Pneumatic Train-Movement Control at the Junction of Three Railroads in Chicago. W Elecn—Dec. 21, 07. 3 figs. 1800 w. 20c.

Weed Burner.

A Railway Weed-Burning Machine Using Gasoline for Fuel. Eng News—Jan. 2, 08. 1 fig. 1200 w. 20c.

Woods for Structures, Preservation of.

The Preservation of Structural Woods for Railways. Martin Schreiber. Elec Tr Wkly—Dec. 19, 07. 1 fig. 3200 w. 20c. Gives original information gathered from many sources, including government tests and reports, etc.

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STREET AND ELECTRIC RAILWAYS.

Broken Axles.

Broken Axles. W. Park. Tramway & Ry Wld—Dec. 5, 07. 10 figs. 1600 w. 40c. Discusses the cause of broken axles on electric cars and suggests remedies.

Car Houses.

Open vs. Closed Terminals for Electric Railway Car Houses. Ry & Eng Rev—Dec. 14, 07. 3 figs. 2200 w. 20c. From report of committee, American Street & Interurban Railway Engineering Assn., Atlantic City, Oct. 14, 07.

The New Fourteenth Street Concrete Storage Car House of the Capital Traction Company, Washington. St Ry Jl—Dec. 21, 07. 18 figs. 3100 w. 20c.

Car Inspection.

The Car Inspection System of the Cleveland Electric Railway. Elec Tr Wkly—Dec. 19, 07. 4 figs. 2600 w. 20c.

Crossing Gate.

Electrically-Operated Crossing Gate. S. Herzog. Génie Civil—Dec. 21, 07. 5 figs. 1200 w. 60c. Describes device used on the grade crossing of a Swiss electric road, the gate being operated by the passage of the train.

Electrically Equipped Roads.

1500-Volt Continuous Current Swiss Railway. S. Herzog. Elek u Masch—Dec. 8, 07. 12 figs. 2000 w. 40c. Gives details of a recently built high-voltage road through the Misoxer Valley.

Single-Phase Equipment of the Windsor, Essex and Lake Shore Rapid Railway. S. C. DeWitt. St Ry Jl—Jan. 11, 08. 6 figs. 3800 w. 20c. Describes the first single-phase railway in Canada.

The Easton & Washington Traction Company. St Ry Jl—Dec. 28, 07. 11 figs. 2200 w. 20c.

The Milwaukee Northern Railway. Ry & Engg Rev—Jan. 11, 08. 7 figs. 2900 w. 20c. Describes road extending north from Milwaukee, Wis., to Cedarburg and Port Washington.

Electric Locomotives.

New Electric Locomotives for the Illinois Traction System. Elec Ry Rev—Dec. 28, 07. 4 figs. 1000 w. 20c.

Motors.

The Design of Car Motors Based on the Best Gear Ratio. P. Gesing. Elek Kraftbetr u Bahn—Nov. 23, 07. 8 figs. 2900 w. 40c.

The Interpole Railway Motor—A Graphic Explanation. Norman G. Meade. Elec Ry Rev—Dec. 28, 07. 9 figs. 600 w. 20c.

Power.

Distribution of Current to Trains on Electric Railways.—III. Ry Engr—Dec., 07. 8 figs. 390 w. 40c.

General Comparison of Continuous and Alternating-Current Traction. Philip Dawson. Elecn—Jan. 3, 08. 4 figs. 300 w. 40c. Sixth instalment of serial on "Electric Traction on Railways."

Single-Phase vs. Continuous Current Motors for Interurban Railway Service. Mech Engr—Dec. 7, 07. 2 figs. 4000 w. 40c. A discussion favoring the use of continuous current.

Power Stations.

Long Island City Power Station of the Pennsylvania Railroad Company. Engg—Nov. 29, 07. 17 figs. 3500 w. Dec. 6. 13 figs. 3000 w. Dec. 20. 10 figs. 4800 w. Each, 40c.

The Market Street Station of the New Orleans Railway & Light Company. Eng Rec—Dec. 7, 07. 3 figs. 4400 w. 20c.

The Reconstruction of the Power System of the New Orleans Railway & Light Company. St Ry Jl—Dec. 7, 07. 26 figs. 9000 w. 20c. Gives detailed descriptions of the principal stations and other important features of the united systems.

Shops.

The Electrical Equipment of the Workshops of the Buenos Ayres Western Railway Company at Liniers. El Engr—Dec. 13, 07. 5 figs. 5400 w. 40c.

Subway, Increasing Capacity of New York.

Methods of Increasing the Capacity of the New York Subway. Eng Rec—Dec. 7, 07. 3200 w. 20c.

Surface Contact System.

The G.-B. Surface Contact System. Prof. J. T. Morris. Elec Engr (Lond)—Jan. 2, 08. 3 figs. 2300 w. 40. A lecture at the Univ. of London on the details of working of the Griffiths-Bedell surface contact-tramway system.

Track.

Contact Resistance in Connection With Rail Bonding. Jl of Worcester Poly Inst—Nov., 07. 7 figs. 1400 w. 40c.

Corrugations on Tramrails. Arthur Thomas Arnall. Elec Engr—Nov. 29, 07. 1 fig. 2700 w. 40c. Paper read before the students' meeting of the Institution of Civil Engineers.

Rail Corrugation. Andrew Forbes. Tramway & Ry Wld—Dec. 5, 07. 6 figs. 1500 w. 40c. Advances suggestions to account for the existence of corrugations on tramway rails.

T-Rail Track in Cities. H. L. Weber. Elec Ry Rev—Nov. 30, 07. 3 figs. 1200 w. 20c.

The Third-Rail Problem. A. D. Williams, Jr. Eng Mag—Dec. 07. 2300 w. 40c.

THE ENGINEERING DIGEST

Vol. III. — MARCH, 1908 — No. 3

ERECTION OF THE MANHATTAN BRIDGE ACROSS THE EAST RIVER

CONDENSED FROM THE "SCIENTIFIC AMERICAN"

The Manhattan Bridge, which is being erected over the East River, will be not only the heaviest suspension bridge in existence, but, for its length, it will be the heaviest bridge of any kind yet built. Although its span will be 140 ft. less than the span of the big cantilevers of the Forth Bridge, the enormous load which the bridge is designed to carry will call for a weight of cables and suspended superstructure, which will easily make this the heaviest and strongest bridge in the world. The Forth Bridge carries only two steam railway tracks; and, although that bridge is such a splendid piece of work that the fastest Scotch express trains run across it at speeds of 60 miles an hour, the live load is small compared with the size and mass of the cantilever. The Manhattan Bridge, on the other hand, will have to carry eight railroad tracks, in addition to a wide roadway for vehicles and two footpaths for pedestrians. The suspension bridge proper, disregarding the approaches, will consist of a main span 1,470 ft. long, and two side spans each 725 ft. in length. The total width of the floor of the bridge will be 120 ft., as compared with the width of 85 ft. of the old Brooklyn Bridge.

The total pull of the four cables amounts to 30,000 tons, and to resist this exceptionally heavy anchorages are provided. Each anchorage covers an area 237 ft. by 181 ft. 10 ins. Their height above ground is 135 ft.; and each contains 115,000 cu. ft. of masonry and weighs 233,000 tons. The anchorages are built on a foundation of piles, which are driven as closely together as they will go under the toe or forward end of the anchorage, where the pressure is greatest, the spacing of the piles widening out toward the rear, where the pressure is least. The anchorages are built of cyclopean rubble and concrete, with a facing of granite. The anchor bars are imbedded in the body of the masonry and anchored to a massive set of anchor girders. There are nine anchor girders to each cable. Eight carry four strands of the cable, and the ninth five strands, there being altogether thirty-seven strands in each cable. The eyebars are 110 ft. long; and the magnitude of this work will be understood, when it is stated that there are altogether six miles of eyebars in each anchorage.

The foundations for the main towers extend 92 ft. below mean high-water level. Each foundation covers an area 78 ft. wide measured in the direction of the length of the bridge, and 144 ft. measured transversely to the bridge. The caissons are 56 ft. in height, and above them the solid masonry of the piers is carried up for a further height of 67 ft., making a total height from foundation to capstone of the piers of 123 ft. The granite surface of the top of the piers is very carefully leveled off, and upon it is laid a wrought-steel pedestal, measuring 18 × 43 ft., the foundation plate of which is 2 ins. in thickness. The pedestal has a total depth of 5½ ft. It is

heavily ribbed, and constitutes one of the most massive and difficult pieces of built-up riveted steel work of its kind ever constructed. On this pedestal rests the steel tower, which consists essentially of four huge box-section legs heavily braced together, each leg having a uniform width transversely to the axis of the bridge of 5 ft., with a length parallel to the axis of the bridge varying from 32 ft. at the base to 10 ft. at the top of the towers. The legs are also stiffened against lateral deformation by two intersecting plate-steel diaphragms of a general I-section, which are 7½ ft. in depth and spaced 2½ ft. each side of the vertical axis of the tower legs. The erection is being done by means of a pair of massive derricks, which are carried upon the tower itself, and hoisted to a new position as soon as the steel work has been built to the full limit of their hoisting capacity. The steel work of the towers is riveted up in complete sections at the steel works, and is delivered at the foot of the towers on barges from which it is hoisted to the top of the piers, to be finally lifted in position by the erecting derricks.

The original design, by former Commissioner Lindenthal, was for an eyebar suspension bridge, the towers of which were to be carried on huge 24-in. pins providing for movement of the towers in the longitudinal plane of the bridge—an excellent arrangement, conducing to great accuracy in the determination of stresses, both in the towers and masonry. When the present plans were substituted, it was decided to dispense with the pins and use the flat footings as described above. At the same time, since the cables were to be rigidly attached to the tops of the towers, it was necessary to make the towers very much heavier, to enable them to withstand the bending stresses which would result from the variations of the loading of the bridge. These bending stresses, under working load, will cause a movement toward the center of the main span of from 6 to 9 ins., and under maximum congested load of 2 ft. 1 in. This means that in addition to the vertical compressive load, due to the weight of the structure, there will be additional loads due to the bending over of the towers toward the center of the span. Hence these towers are necessarily very heavy, the total weight of steel in each one being 6,500 tons, or from 1,500 to 1,700 tons more than would have been necessary had the towers been free to move on pins at their base. The total load on each tower is 32,000 tons under the maximum possible congestion of traffic on the bridge. The area of the metal in the towers at the top is 4,400 sq. ins., and at the base 14,800 sq. ins. The maximum possible unit pressure on the steel of the towers at the base, under congestive load, is 27,500 lbs. per sq. in., this including both the vertical loads and the stresses due to the bending of the towers. The maximum unit stress under the reasonable ordinary working load will be 20,000 lbs. per sq. in. It should be explained here that the maximum congested load with four tracks crowded from end to end, the roadway a continuous jam of vehicles, and the footpath crowded with people, is 8 tons per linear foot of the bridge, and the maximum assumed working or ordinary load is 4 tons per linear foot.

The main cables are 21¼ ins. in diameter measured on the wires without the wrapping or sheathing. Each of the four cables contains 9,472 wires, 3/16 in. in diameter, all of which are galvanized. The total length of single wire in all the four cables will be 23,100 miles, or nearly sufficient to girdle the entire earth. The wire will have an ultimate strength of 215,000 lbs. per sq. in., and the main cables will be subjected to a working load of 60,000 lbs., and a congestive load of 73,000 lbs. per sq. in.

The suspended roadway will consist of four trusses, carried in the planes of the legs of the towers, each truss being 24 ft. deep center to center of chords. Each pair of trusses will measure 28 ft. from center to center, with a spacing of 40 ft. between the inside trusses. The four railroad tracks will be carried, two of them on the lower, and two of them on the upper, deck of the trusses. The two footways, each 10 ft. wide, will be carried on the outside of the outer trusses, on cantilever extensions of the floor beams. The central roadway for vehicles, 35 ft. wide, will occupy the center of the bridge on the level of the lower deck of the trusses.

A novel feature will be the use of nickel steel in the upper and lower truss chords, which will be subjected to a working stress of 40,000 lbs. per sq. in. The nickel-steel rivets will be subject to a working stress of 20,000 lbs. per sq. in. In spite of the higher cost of the nickel steel, the saving in weight will be such as to make the trusses actually cheaper than if they were built entirely of ordinary structural steel. The weight of steel in the superstructure from anchorage to anchorage, exclusive of the cables, is 10,500 tons of carbon steel and 8,000 tons of nickel steel. The weight of the cables is 6,300 tons, and the total weight of steel in the whole bridge, in-

Courtesy of the "Scientific American."

VIEW FROM BROOKLYN SIDE, SHOWING BROOKLYN AND MANHATTAN TOWERS, AND OLD BROOKLYN BRIDGE TO THE LEFT.

cluding anchor chains, cables, towers, and suspended span, is 42,000 tons.

In spite of the great weight and carrying capacity of the bridge, it will, in its completed form, be characterized by much of that delicacy and grace of appearance which has made the Brooklyn Bridge so justly famous, and the absence of which renders the Williamsburg Bridge one of the ugliest structures of its kind ever erected.

RECENT EXPERIMENTS ON WIND PRESSURE

Results of an extended series of experiments on wind pressure, by M. Eiffel, the well-known French engineer, have recently been published in pamphlet form, under the title of "Recherches Expérimentales sur la Résistance de l'Air Exécutées à la Tour Eiffel." For the purpose of obtaining precise data on the subject, M. Eiffel had recourse to a novel method which consisted in letting fall vertically the plates or wind boards offering the surfaces to be tested, from a height of about 400 ft. in the Eiffel Tower. Above the wind board and attached thereto by springs was a cylindrical case containing suitable dynometric and recording apparatus. Through the axis of this case was a hole, through which a cable passed, and it was this which guided the assemblage in its fall. The cable was a very loose fit, but at about 60 ft. above ground its section gradually enlarged, as the earth was approached,

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thus braking the apparatus and bringing it to rest without shock or damage. M. Eiffel found that, within the limits of his experiments—for velocities of from 60 to 130 ft. per sec.—that the resistance offered by air to a moving surface is practically proportional to the square of the velocity, although the exponent increases slightly and gradually when velocities exceeding 100 ft. per sec. are employed.

The resistance or pressure in pounds, P, is represented by the product KSV^2, where K is a constant depending on the size and shape of the surface tested; S is the area of the surface in square feet, and V is the velocity in miles per hour. At ordinary temperatures and a barometric pressure of 760 mm., M. Eiffel found that the value of the coefficient K ranged from 0.00286 to 0.00327, the latter value being apparently a maximum attained only with large surfaces. Thus, for a circular surface of 1 sq. ft., the value of K was 0.00286, for a square surface of the same area, 0.00295, and for an area of 10 sq. ft., 0.00323. He also found that the resistance of an inclined surface is practically the same as that of a normal one, when the perpendicular to the surface makes an angle less than 30° with the direction of motion. For greater angles the resistance proportionally decreases (zero at 90°).

It is interesting to compare the values of K obtained by M. Eiffel with those recently reported in a paper read by Dr. T. E. Stanton, before the Institution of Civil Engineers. On pressure boards ranging from 25 to 100 sq. ft. in area, which were mounted at the top of a 50-ft. tower, Dr. Stanton found, from a large number of experiments, that the mean value of this constant was 0.0032, which strikingly corroborates the results of M. Eiffel. The results of M. Eiffel were obtained with wind velocities of from 40 to 90 miles per hour; the velocities in Dr. Stanton's experiments have not been mentioned in any of the recently published reports of his paper.

ELECTRIC WELDING BY THE BENARDOS PROCESS

By C. B. AUEL

CONDENSED FROM "THE ELECTRIC JOURNAL"

In the Benardos process an arc is drawn directly between the metal to be welded, which forms one terminal of an electric circuit, and a carbon electrode, which forms the other terminal.

It is the purpose to describe here in detail this process and its application in connection with steel castings, pipes and plates, though it has a considerably wider range of usefulness.

Apparatus.—The outfit required for the welding of steel castings includes a direct-current source of supply, a rheostat, a carbon electrode and fire-clay or carbon blocks for molding purposes. An enclosure should be provided in which to carry on operations, for the glare from the arc is very intense and would seriously interfere with any other work in the immediate vicinity. The operator should have all parts of his body well covered (the clothing is quite sufficient), as even a few minutes' exposure to the rays will produce an irritating effect like sunburn upon the skin, resulting in a reddening and subsequent peeling of it with, however, no more serious consequences. For the head a canvas hood is generally used, being fitted with a small window of colored glass, through which the welding operation is watched without risk of injury to the eyes. The hands are usually protected by buckskin gloves provided with gauntlets to cover the wrists.

Current may be obtained from a 100 to 125-volt supply circuit. Assuming, however, that there will be sufficient welding to keep at least one man steadily employed, and taking into account first cost, subsequent maintenance, continuity of operation, simplicity and non-interference with other portions of the electrical plant, an independently-driven dynamo is perhaps to be preferred. It is of the utmost importance that the supply be of ample capacity, for more failures may be traced to an inadequate supply than to any other one

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cause The dynamo should, therefore, be of about 75 to 100-KW. capacity at 100 to 125 volts, shunt or compound-wound, belt-driven or direct-connected; if the latter, a flexible coupling must be used, otherwise armature burn-outs are likely to be of frequent occurrence. With the dynamo should be provided a small switchboard having mounted on it the necessary instruments, voltmeter, ammeter, circuit breaker, field rheostat and switch. If the dynamo is driven by a motor instead of by an engine, one or two additional instruments will be required for the control of the motor.

A very satisfactory rheostat is easily constructed by using two watertight barrels placed side by side. The positive cable of the circuit is carried from the dynamo to the switchboard and from the switchboard to the water rheostat. At the rheostat this cable divides into two smaller ones, these being fastened to separate triangular steel plates not less than ¼ in. thick, suspended above the barrels by means of pulleys and counterweights, so that the plates may be readily lowered into or withdrawn from the barrels as occasion requires the adjusting of the water resistance. Similar cables are run down the inside of each barrel and one end likewise fastened to a heavy plate of steel, which lies on the bottom. The other end of each of these cables is attached to the casting to be welded or the cables may be fastened to a metal table and the casting simply laid upon it, always providing good contact is made. The negative cable of the circuit is carried from the dynamo to the switchboard and from the switchboard to the vicinity of the casting to be welded, where it is provided with a metal terminal and clamp, into which the carbon electrode is tightly fitted. In order to manipulate the carbon electrode during welding, the negative terminal is held in a wood insulating handle, to which is attached a shield of asbestos or other fireproof insulating material.

The selection of the proper carbon requires some care, and while almost any kind may be used, such will not give the best results. Experience seems to indicate as best for heavy work, a hard, solid (not cored) carbon of 1 or 1½ ins. in diameter, 6 to 12 ins. in length, and one that, as it wears away, leaves a round stub end and not a long pencil point. For lighter work, a carbon of smaller diameter will suffice.

In the general repair of steel castings, iron rod of about ⅜-in. diameter is used for filling (Norway iron is preferable), although small pellets from scrap boiler plates or steel castings may also be used, the choice between the rod and the pellets depending, to a certain extent, upon whether the weld is small or large.

Method of Making a Weld.—As before mentioned, the positive terminal of the circuit may be clamped directly to the casting to be welded, or it may simply be laid upon a metal table and the terminal clamped to the latter. The positive terminal is thus connected instead of the negative terminal so as to direct the flow of current from the casting to the carbon electrode, and in this way prevent carbon, when the electrode is vaporized, from entering the weld. The steel plates of the water rheostat are lowered into the barrels which have been previously filled with water, the circuit breaker and the switch closed, when the actual welding is ready to be undertaken.

The operator places himself directly in front of the casting, holding the negative terminal with its carbon electrode in one hand by means of the wood insulating handle, and having within reach of the other hand several pieces of iron rod. He then pulls the canvas cap well down over his head, touches the carbon to the casting, thereby closing the circuit and thus producing an arc. As soon as the arc is sprung, the carbon is withdrawn to a distance of 2 ins. or more (too short an arc will tend to produce a hard weld), and the arc allowed to play upon the casting until the metal commences to boil. It is advisable not to concentrate the arc on any one spot, but to give it a circular movement so as to heat the casting very thoroughly within the immediate vicinity of the proposed weld. This will tend to prevent too rapid cooling of the metal with its consequent chilling and hardening effect. The end of one of the iron rods is now placed directly in the midst of the boiling metal, where it gradually melts and mixes with it, the arc meanwhile being continued. As the rod melts away it is fed into the weld and this process is continued with one or more additional pieces of rod until the weld has been completed. The surface of the weld may be hammered as it cools off to produce a closer grain or to make it conform to some particular shape.

When pellets are used instead of the iron rod they are placed in the weld or cavity, a few at a time, and the arc applied, more pellets being added as the first batch is melted.

Should the part of the casting to be welded

present a dirty appearance or contain slag, it should first be cleaned by means of a chisel or by tilting the casting so as to allow the dirt or slag to drop off as fast as it melts when the arc is applied. After cleaning in this manner the casting is tilted back and the welding then proceeded with.

If possible, the weld should be made with one continuous application of the arc, as oxide of iron (scale) will form with each cooling and if not removed will assist in producing a very hard weld, that is, one not easily machined. Where, however, it is not possible to make the weld with one application of the arc, the scale should be brushed off by means of a stiff wire brush. Hammering the weld after cooling will also very materially assist in this cleaning.

When, instead of a cavity to be filled, it is necessary to build up a lug or to weld a piece to the casting, fire-clay or carbon blocks may be used for the purpose of confining the molten metal within certain desired limits or of having it assume a definite shape.

When the work is properly done, welds made by this method will give an average tensile strength equal to 70 or more per cent. of the original stock.

It would be exceedingly difficult, if not impossible, to set forth in exact terms the relations existing between current, size of weld, time required for weld, etc., on account of the different variables which enter in, but the following data, obtained in welding a lug 1¼ ins. in diameter and 2 ins. thick to a casting, are approximately correct and will enable a rough idea to be formed of the magnitude of the several items involved:

Time for welding, 56 secs.; amperes, 600; volts across rheostat, 42; volts across arc, including carbon, 58; total line volts, 100; size of carbon, 1½ in. diam. × 6 ins.

Besides the welding of steel castings the Benardos process may be advantageously employed in the removal of surplus metal, including sink heads, in the boring of large holes in castings or plates, in the welding of flanges, elbows and couplings to pipes, and in a variety of other ways.

The Benardos process gives thoroughly satisfactory results commercially; and is one which can easily be learned by any workman of average ability, after a few weeks' practice. The welds first made will generally be harder to machine than the other portions of the casting, but increasing familiarity with the process will reduce the number of such hard welds to a minimum.

STRESSES IN DAMS

At a recent meeting of the Institution of Civil Engineers, two interesting papers on this subject were presented, namely, "Experimental Investigations on the Stresses in Masonry Dams Subjected to Water Pressure," by Sir John W. Ottley and A. W. Brightmore, D.Sc., and "Stresses in Dams: An Experimental Investigation by Means of India-Rubber Models," by Messrs. J. S. Wilson and W. Gore.

The experiments described in the first paper occupied about fourteen months and were restricted to models of a dam of typical triangular section under perfect conditions. The models were made of "plasticine," a kind of modeling clay, which appeared likely to reproduce on a small scale many of the conditions existing in a "full-size" structure.

The dam was first modeled of triangular section with the vertical face exposed to the pressure of the water, the base being made equal to the height divided by the square root of the specific gravity of the "plasticine," so that the resultant of the pressure on the base —due to the weight of the model dam itself and the pressure of the water—would act at one-third of the width of the base from the outer toe. Water pressure was applied to the face of the model by water contained in a thin rectangular india-rubber bag made to fit the frame.

The following conclusions were drawn: (1) If a masonry dam be designed on the assumption that the stresses on the base are "uniformly varying," and that these stresses are parallel to the resulting force acting on the base, the actual normal and shearing stresses, on both horizontal and vertical planes, would —in the absence of stresses due to such factors as changes in temperature, unequal settlement, etc.—be less than those provided for; (2) there can be no tension on any plane at points near the outer toe; (3) there will be tension on planes other than the horizontal plane near the inner toe; the maximum inten-

sity of such tension being generally equal to the average intensity of shearing stress on the base, and the inclination of its plane of action being about 45°.

In the second paper the authors described experiments made with models of india rubber, the use of this material having been suggested to them by the description given by the late Sir Benjamin Baker of investigations made by him with jelly models. Three sets of experiments were carried out and the strains of the models were recorded by the aid of photography.

The following are some of the conclusions given in the paper: (1) Tensile stresses may exist at the up-stream toe of a dam, notwithstanding the fact that the line of resistance lies well within the middle third. The tension may be reduced by (a) making the up-stream face vertical, or by otherwise increasing the weight of the dam toward that face; this would have the effect of increasing the stresses in the dam when the reservoir is empty; (b) by a general increase in the dimensions of the dam; (c) by placing an earth embankment against the down-stream face. (2) The direct stresses at the down-stream toe are compressive in every direction, but reduce to zero in the direction normal to the face. (3) The maximum compressive stresses in a dam above its foundations are in a direction approximately parallel with the down-stream face and generally some distance therefrom. In magnitude they are slightly greater than $P/\cos^2 \theta$, where P is the maximum normal pressure on a horizontal plane as determined by the trapezium law, and θ is the angle between the resultant and the vertical. (4) The shearing stresses are considerable at or near the up-stream toe. They are a maximum a short distance from the down-stream face, in a plane approximately at 45° to the face. The maximum shearing stresses are in magnitude equal to $P/2 \cos^2 \theta$. (5) The stresses in the foundations are of less consequence than in the dam above the base, because of the lateral support and the more extended distribution. (6) The stresses are considerable at the toes of a dam if they form sharp angles with the foundations. These stresses may be reduced by replacing the angles with curves of large radii. The curve at the up-stream toe may take the form of a rounded quoin, cut in large stones, so as to avoid joints, in the masonry, normal to the direction of the greatest tensile stress.

THE MANUFACTURE OF COMMERCIAL PORTLAND CEMENT

By RICHARD K. MEADE

CONDENSED FROM "MINING SCIENCE"

The rotary kiln is the form now universally used in this country for burning cement, as it allows the material to be fed directly into it, either in the form of a powder or a slurry, thus saving much labor.

In its usual form it consists of a cylinder, from 6 ft. to 8 ft. in diameter and from 60 ft. to 150 ft. long, made of sheet steel and lined with fire brick. The steel sheets are from ½ in. to 9-16 in. thick, and are held together by single-strap butt joints. This long cylinder is supported at a very slight pitch (¾ in. to the foot) from the horizontal, on two or more tires made of rolled steel, which in turn revolve on heavy friction rollers. The kiln is driven at a speed of from 1 turn a minute to a turn in 2 minutes by a girth-gear, situated usually near its middle, and a train of gears. The power is supplied by either a line shaft or a motor. The upper end of the kiln projects into a brick flue, which is surmounted by a steel stack, also lined with fire-brick for its entire height. The flue is provided with a door at the bottom, which serves not only to allow the flue to be cleared of the dust which accumulates in it, but also as a damper to control the draft of the kiln.

The material to be burned is usually fed into the kiln through a horizontal water-jacketed screw conveyor, or else spouted into it through an inclined cast-iron pipe. When slurry is to be burned this is pumped into

the kiln. The dry raw material is kept in large steel bins above the feeding device, while slurry is stored in vats, in order, in either case, to have on hand a constant and regular supply. The raw material feeding device is usually attached to the driving gear of the kiln, so that when the kiln stops the feed also stops.

The lower end of the kiln is closed by a fire-brick hood. This is usually mounted on rollers, so it can be moved away from the kiln when the latter has to be relined. The hood is provided with two openings, one for the entrance and support of the fuel-burning apparatus, and the other for observing the operation, temperature, etc., of the kiln, and through which bars may be inserted to break up the rings of material which form, and to patch and repair the lining. The lower part of the hood is left partly open. Through this opening the clinker falls out and most of the air for combustion enters.

The kiln is heated by a jet of burning fuel, usually powdered coal, but sometimes (as in Kansas) natural gas and (as in California) fuel oil are used. The coal is blown in by a blast of air supplied by either a fan or air compressor. If the fan is used, about 20% of the air necessary for combustion is supplied this way. If the compressor is employed, only 5% to 10% of the air is delivered by the compressor.

The necessary temperature of the hottest part of the kiln is about 3,000° F., and is rarely ever less than 2,700° F. To maintain this temperature properly about 80 lbs. to 160 lbs. of fuel are required per barrel of cement, the actual amount depending on the coal itself, the material to be burned and the dimensions of the kiln. The larger the kiln the greater economy it will show. Dry materials require much less coal than slurry. With limestone and shale mixture, and a kiln 100 ft. long by 7 ft. in diameter, the coal consumption will amount to about 90 lbs. of good gas-slack per barrel. A kiln 60 ft. long by 6 ft. in diameter will, on the other hand, require about 110 lbs. of this material per barrel.

Of the heat supplied to the kiln by the burning of the coal, by far the larger proportion is wasted. About 50% to 75% of it is carried off by the waste gases of the stack, and from 10% to 15% by the hot clinker falling from the lower end of the kiln. The gases enter the stack at from 1,500° to 2,000° F., and the clinker leaves the kiln at not much under 2,000° F. If the kiln could be made to show the same economy as is common in good kiln practice, a barrel of cement could be burned with 25 lbs. of coal.

The raw material as it enters the kiln contains about 33% carbon dioxide. For the first 30 ft. of its journey through a 100-ft. kiln, it is merely heated up and whatever water it contains is driven off. In the next 40 ft. it loses all its carbon dioxide and sticks together, forming small, soft, lemon-yellow balls, which, as they reach the hottest part of the kiln, the last 30 feet, partially vitrify, become rough and hard, and turn to a greenish-black color. Properly burned Portland cement clinker is greenish-black in color, of vitreous luster, and usually, when just cooled, sparkles with little bright, glistening specks. It forms in lumps from the size of a walnut to hardly more than dust, with here and there a larger lump. Under-burned clinker is more or less soft, is irregular in shape and not so black as the well-burned material. Under-burned clinker usually shows soft brown centers, but hard brown centers are due to very hard burning.

When coal is used for burning, this is pulverized in mills similar to those used for grinding the raw materials. It is, however, first crushed by passing it through rolls or pot-crushers, and then dried in rotary dryers of special type. The mills most used for coal pulverizing are the Fuller mill and the tube mill. The latter need not be preceded by a ball mill. The coal should be pulverized so that 90% of it will pass a sieve having 100 meshes to the linear in., and should contain from 30% to 45% volatile matter.

As the clinker leaves the kiln at about 2,000° F., it is entirely too hot to grind, and must be cooled to ordinary air temperatures. This can be done by allowing it to lie in piles; but, as it is a slow way of doing it, mechanical devices are usually resorted to. These may consist of either revolving horizontal cylinders or vertical stationary coolers. The former consist of steel cylinders, provided with angle irons on their insides to carry the material up and drop it through the current of air passing through the cylinders. They are mounted on tires and rollers, just as are kilns and dryers, and revolve at a speed of about a turn or two a min. They are usually placed below the kiln and the clinker falls from the kiln into them. The air for cooling is also drawn through them into the kiln by the draft of the latter. They thus serve, not only to cool the clinker, but also to prevent the air entering the kiln.

The vertical cooler consists of an upright steel cylinder, 8 ft. in diameter and 35 ft. high, provided with baffle plates and shelves. As the clinker falls over these, it meets a current of air blown in through a perforated pipe running up through the center of the cylinder, and is thus cooled. The clinker is carried from the kiln into these latter coolers by means of bucket elevators, water being run into the buckets to geep them cool. This also suddenly chills the clinker and makes it brittle and easier to grind.

After cooling, the clinker is ground in Fuller mills, Griffin mills or ball and tube mills. In the case of Fuller and Griffin mills, it is usually found more economical to crush the clinker down to pea size by a set of rolls, before feeding to the mills. A mill similar to the Fuller mill, except that it has no screens, is used as a preliminary grinder to the former mill, thereby greatly increasing its efficiency. Kent mills and air separators, and also Kent mills, which grind as preparation for the other mills, are used to a limited extent. The clinker should be ground so fine that at least 92% of it passes a sieve having 100 meshes to the linear inch.

In order to regulate the set of the cement, since clinker ground alone would set very rapidly, it is necessary to add to it calcium sulphate in some form or other, usually as of gypsum, or plaster of paris. As this can be most easily mixed with the cement during grinding, it is the usual practice to add the retarder to the clinker before the latter is ground, and to grind the two together. The amount of gypsum or plaster of paris used is usually about 2% or 3% of the weight of the clinker.

After passing through the clinker mills, the cement is conveyed to the stock house. This usually consists of a long, low building of wood, stone or concrete, cut up into bins. The cement is brought in by an overhead screw-conveyor and dropped into any desired bin by means of a slide in the bottom of the conveyor trough. A screw-conveyor also runs under the floor of the stock house, at the ends of the bins. The latter are provided with removable board ends, and, when it is desired to pack from any bin, these ends are removed and the cement allowed to run into the screw-conveyor. When the cement ceases to run, it is necessary to either pull it into the conveyor with a broad-blade hoe, or else to wheel it there in barrows. The screw conveyors then carry it to the packing machines, which are similar to those used in flour mills.

Cement is packed into barrels holdings 380 lbs., or into paper or cloth bags holding 95 lbs. each. The cement is packed as shipped and the bags or barrels are trucked directly to the cars. For this reason the packing-room floor is on a level with the floor of the cars to be loaded, and these latter are brought alongside of the room. A shed roof should run out over the cars, so the loading can be done in stormy weather. Cars usually hold from 100 bbls. to 170 bbls. of cement, with 150 bbls. for an average.

Much more cement is packed in cloth bags than in anything else. In the case of these bags, the consumer is charged with the value of the bag, and credited by a certain amount if the bag is returned in good condition. The bags are all marked with the brand label of the manufacturer, and so each manufacturer knows his own bags. Barrels and paper bags are sold to the customer and are not returnable.

To give an idea of the power required to make cement, it may be roughly stated that 2,000 engine HP. will be sufficient to make 2,000 barrels per day.

Most of the modern Portland cement plants manufacture at least 2,000 bbls. of cement per day, and many of them even much more than this. In the manufacture of a barrel of cement over 1,100 lbs. of material must be ground to an impalpable fineness, and when Portland cement is selling for $1 a barrel at the mill, the need for doing things on a large scale will be understood. To grind this amount of material economically, only the most efficient machinery will serve, and where this is installed, it is possible to do this amount of grinding for less than 25 cents. This is, of course, only one of the items entering into the cost of manufacturing a barrel of cement, but it serves to illustrate the point of economy reached in the industry. As to the cost of the plants themselves, the newer plants now under construction will probably cost, exclusive of land, etc., about $1 for each barrel of annual capacity; or, in other words, a plant producing 2,000 bbls. per day should cost approximately $700,000.

PHYSICAL CHARACTERISTICS OF CAST IRON*

By JAMES CHRISTIE

Cast iron is probably the most complex, variable and uncertain form in which iron is used. Not only is the content of extraneous metals and metalloids variable, but the condition in which the associated carbon exists and the character of this association are determined largely by the influence of silicon and possibly other metalloids. Again, the physical properties of the metal are influenced by casting temperature, rate of cooling, etc., so that altogether we can only predicate the probable strength and stiffness of a casting in the most general way, and forecast results which will suit an average from which individual castings may vary widely in extremes. Gray iron of the foundry grades is alone considered here. The grading of the pig metal at the furnace has been determined in the past by the appearance of the fracture, but recently, as much of the product is run in metal molds and the appearance of the fracture is deceptive, the tendency is to grade by chemical composition, the softer and weaker metals having the highest silicon and the lowest percentage of combined carbon. Taking three grades of foundry pig and assuming that these are used for different classes of castings we would have:

No. 1—2.5 to 3% silicon for light castings.
No. 2—2 to 2.5% silicon for medium weight castings.
No. 3—1.5 to 2% silicon for heavy weight castings.

As a general average, all the grades will carry about 3.5% carbon in total.

Physical Properties.—The recent specifications of the American Society for Testing Materials require a transverse test on specimens 1¼ in. in diameter and 12 ins. between supports, load in the middle:

2,500 lbs. or over for light castings.
2,900 lbs. or over for medium castings.
3,300 lbs. or over for heavy castings.

with deflection before rupture not less than 1-10 in. The tensile strength of the aforesaid grades respectively is required to be not less than 18,000, 21,000 and 24,000 lbs. per square inch of section. While these standards are valuable in maintaining a high quality of product, yet they may imperfectly represent the resistance of the metals in actual service. We know that cast iron is in extensive use that falls far short of these requirements. High tensile strength is frequently associated with brittleness and is not always indicative of superiority.

For heavy machinery, etc., cast iron is used in heavy masses, through which working stresses are imperfectly distributed, and probably is much softer and weaker in the middle of the mass, where it has cooled slowly, than at outer surfaces, where the metal has more rapidly cooled. Furthermore, castings are usually under considerable internal strain, due to unequal contraction, and although this internal strain gradually disappears it may have some disturbing influence after the casting has been put in service. It has been the practice of the writer to assume an ultimate tensile strength of 16,000 lbs. per sq. in. for ordinary iron castings, and to limit working stresses from 2,000 to 4,000 lbs. per sq. in., according to the conditions and character of the service.

Cast iron offers a high resistance to compressive stress, and although this resistance varies within wide limitations, it may be assumed as a working basis to be about six times that of the tensile strength, or, say 95,000 lbs. per sq. in. of section.

Cast iron is imperfectly elastic as compared with the superior forms of the metal. It presents no definable elastic limit and exhibits marked permanent set under low loads, either in tension or compression. Experiments continued for several years indicate that when loads exceeding one-half the ultimate are applied, failure eventually ensues. It may therefore be assumed to have a practical elastic limit in tension of about one-half the breaking load.

The coefficient of elasticity is likewise variable, in contradistinction to the constancy of the elasticity, under ordinary conditions, of wrought iron and steel.

*A paper read before the Engineers' Club of Philadelphia.

Recorded experiments indicate that the modulus of elasticity varies considerably in extreme cases, and is nearly alike in tension and compression. A modulus of 13,000,000 lbs. appears to be a fair valuation for direct tension and compression or, for bending loads, applied transversely this modulus appears to average 16,000,000 lbs. when used in computation with the commonly accepted formula for flexure.

Cast Iron in Structural Uses.—In the middle of the past century, as cast iron became extensively applied to structural purposes, its physical properties were studied with great care, and the experiments of Hodgkinson and Fairbairn in England and their contemporaries yielded a fund of information on the subject. Seeking a section of beam which should exhibit the highest ultimate strength in proportion to area of cross-section or of the weight of metal employed, Hodgkinson advocated a section in which the tension flange exceeded the compression flange about six to one in sectional area, the web usually tapering in thickness from the tension flange, diminishing toward the other flange. This form of beam was largely adopted and took precedence as long as cast iron was used for beams in structures. We find that the same method of reasoning influenced the machine designer in disposing cast iron to seeming advantage in the construction of machines, massing the metal to resist tension and permitting high unit stress on metal in compression. Especially is this observed in machines of the open-jaw or gap type, such as presses and punching and shearing machines. The writer believes that usually the unit stresses should be little if any higher in compression than in tension, for the following reasons: In machinery rigidity or stiffness is usually the chief consideration. Many machines do not fulfill the intended purpose properly, not by failure through fracture, but by a want of sufficient stiffness. Deflection has to be limited, and when that is done breaking from excessive tension is sufficiently guarded. Remembering that cast iron yields to compression as much as with the same unit stresses it yields to tension, it follows that the compressive stress should not exceed the tensile strength per unit of section if it is desired to dispose a given mass of metal with least deflection. It is believed that rupture sometimes occurs in a machine apparently through tension, where the origin of the weakness could be traced to a want of material sufficiently to resist compression, the improperly supported tension side severing by cross-bending or transverse stress.

For example, in an open-gap machine, if the section is so shaped that compressive unit stress is six times that of the tensile unit stress, then, elastic moduli being equal, the frame will yield at the outer flange C six times as much by compression as it does by tension at the inner flange T. This permits an oscillation of the mass at T around its center. If this oscillation becomes dangerous, by extent or frequency, the frame will break by cross bending at the mass T, giving the impression that more material is needed to resist tension; whereas the fact may be that more material should be placed at C to prevent excessive yield by compression.

Inadequacy of Theoretical Calculations.—Owing to the peculiar physical characteristics of cast iron, it has not been found practicable to harmonize experiments with the theory of flexure. Many reasons are offered for this, and modifications of the usual accepted theory have been propounded which will not be discussed here. It has been found necessary to introduce into the equations moduli or coefficients which have no apparent relation to the direct strength of the metal, and which vary widely for different dimensions and shapes of cross sections. As the cross sections under consideration are frequently of unsymmetrical and irregular shape, the computation of flexural moments is tedious and frequently useless if the computer has not a correct modulus to apply to satisfy the conditions of the section under consideration. It is therefore desirable for the designer to keep a record of experiments and of failure of castings under known loadings, and from these results derive coefficients by means of which the strength and stiffness of various sections can be approximately known without recourse to the usual calculation for the resisting moments of the section.

In machinery the working stresses are usually impulsively or suddenly applied, sometimes with actual percussion or impact, and frequently alternate stresses of equal intensity in opposite directions occur in rapid reciprocation. As it is known that a load so rapidly applied as to permit the unimpeded effect of gravity will produce a deflection double that due to the static effect of the same load, it can be seen that the total amplitude of vibration due to rapidly alternating loads must be very considerable. To prevent excessive vibration the structure should be designed with a limitation of deflection in

view, and the amount of this limitation is derived solely from experience and should be governed largely by the nature of the service to which the material will be applied. For machinery under ordinary circumstances we might assume, in order to obtain satisfactory stiffness, that the deflection should not exceed one-twenty-five hundredth part of the span, and under certain conditions should be much less than this. Indeed, it is quite probable that a deflection in direct proportion to length is not advisable, but that the ratio of deflection to length should decrease as length is increased. For long members in compression the sectional area must be augmented as the ratio of length to cross section increases, but for members under variable tension alone the section should be increased also, or the stress per unit of cross section reduced, as the ratio of length to cross sections increases, for the purpose of reducing vibration due to successive extensions.

When rapidly alternating stresses occur, it is acknowledged that provision must be made for something more than the greatest stress in one direction alone. There are still differences of opinion and practice on this subject among bridge designers. Some maintain that when the alterations are of slow recurrence, so as to permit actual rest between reversals, no special increase of section is required. Others specify that the sum of the sections required for the stresses in opposite directions should be used to suit the conditions. There can be little doubt that the latter estimate is little enough for machinery when the oscillation of the forces occurs with great rapidity, and especially when the metal under consideration is cast iron, with a modulus of elasticity about one-half that of steel or wrought iron. It is a safe general rule for ordinary cast iron in machine structures to limit tensile stress to 4,000 lbs. per sq. in. of section under the most favorable circumstances, to 3,000 lbs. when loads are suddenly applied and to 2,000 lbs. when the force alternates in direction. These unit loads should be further limited to suit the ratio of length to section, as required for columns or any members in alternate extension or compression. For beams or members subjected to alternating transverse stresses, the unit stresses on the material should be limited so that the sum of the deflections in opposite directions will not exceed one-two thousand five hundredth part of the span, or such other limitation as, according to the judgment of the designer, will provide sufficient stiffness for the intended purpose.

RELATIVE STRENGTHS OF NICKEL-STEEL AND CARBON-STEEL COLUMNS

Particulars regarding a series of tests made primarily to determine the relative strengths of carbon-steel and nickel-steel, were given in an article by Dr. J. A. L. Waddell in a recent issue of "Engineering News." The tests comprised three long columns and three short pin-ended columns constructed of each metal. They were composed of two built channels, each consisting of two 3 × 3 × ⅜-in. angles and one 12 × ⅜-in. plate, connected at the ends by batten plates and laced with 2½ × ⅜-in. bars. The webs were heavily reinforced for bearing and for the transmission of the stress from the pin to the column section in order to insure that the failure of the columns would be in the body and not in the details. The lengths between centers of pins were 10 ft. for the short struts and 30 ft. for the long ones; and the radius of gyration was 4.46 ins., making the values of l/r respectively 27 and 81. The area of the section was 17.44 sq. ins.

The carbon-steel struts were built of railway bridge steel having an ultimate strength between 60,000 lbs. and 70,000 lbs. per sq. in. and an elastic limit of not less than 35,000 lbs. per sq. in. The nickel-steel used was obtained from special melts, and had an ultimate strength between 100,000 lbs. and 115,000 lbs. per sq. in. and an elastic limit not less than 60,000 lbs. per sq. in. The nickel-steel contained approximately the following percentages of materials:

	Per cent.
Nickel	3.50
Carbon	0.38
Manganese	0.75
Sulphur	0.30
Phosphorus	0.015
Silicon	0.05

The following are averages of the results obtained:

		Elastic limit.	Ultimate Strength.
Nickel-steel columns,	10 ft.	52,800	68,700
" "	30 ft.	41,200	44,700
Carbon-steel "	10 ft.	28,800	39,200
" "	30 ft.	21,300	30,500

In designing struts Dr. Waddell uses the following formulas for determining the allowed loading:

For carbon-steel struts with hinged ends,
$$I = 16{,}000 - 80\ l/r;$$
For nickel-steel struts with hinged ends,
$$I = 27{,}000 - 160\ l/r.$$

Comparing the values obtained from these formulas with the elastic limits of the various columns shows the factors of safety (E/I) to be as follows:

Columns—	I.	Elastic limit (E).	E/I.
Nickel-steel, 10 ft.	22,680	52,800	2.33
" 30 ft.	14,040	41,200	2.94
Carbon-steel, 10 ft.	13,840	28,800	2.08
" 30 ft.	9,520	21,300	2.24

Dr. Waddell is of the opinion that if the equivalent static load is less than one-half of the elastic limit, perfect safety is attained. The foregoing table shows that his formulas give values well within this figure. He further believes that the recently suggested addition of 30% to the working intensities to meet the condition of a combination of the greatest equivalent static load and the maximum wind load is more in the nature of a salve to the designer's conscience than an attempt to meet actual conditions; because a simultaneous application of the greatest live-load, greatest impact, and greatest wind pressure, is almost an impossibility; and in view of this, if it ever did happen, the straining for an instant of a few members to 65% of their elastic limits would do no harm.

THE CONSTRUCTION AND OPERATION OF CABLEWAYS*

WITH ANALYTICAL AND GRAPHICAL ANALYSES OF STRESSES

By F. T. RUBIDGE, E. M.

SLIGHTLY CONDENSED FROM "THE UNIVERSITY OF COLORADO JOURNAL OF ENGINEERING"

Definitions.—A cableway is a hoisting and conveying system, consisting of a single span of cable upon which is mounted a carriage with the necessary sheaves, ropes and power to hoist a load from any point and convey it to any other point beneath the cable. The motive power may be installed upon the carriage itself or transmitted from an engine at either end of the span.

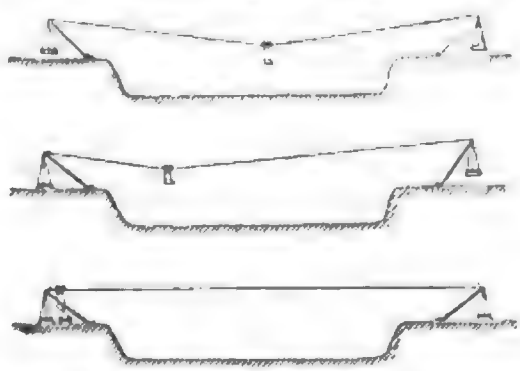
A horizontal cableway is one in which the ends of the span may be on the same or different levels. It is, therefore, of general application.

An incline cableway is one in which, by reason of a sufficient inclination of the cable, the power required to hoist the load is less than that required for conveying. This enables the use of a single rope for both hoisting and conveying.

HORIZONTAL CABLEWAYS.

In this system it is obvious that, in addition to the cable and the carriage which travels upon it, there must be provided independent means for hoisting and conveying the load.

In the case where the motor is installed upon the carriage the latter is propelled by gearing to the sheaves traveling upon the main cable, causing them to act as drivers. The path which the carriage travels when both ends of the main cable are fixed is approximately an ellipse. It is apparent that under such conditions the inclination near the ends of the span is such that it would be impossible



(Load at center; skip moving toward left; skip at shears and dumping load.)

FIG. 1. BALANCED CABLE CRANE HORIZONTAL CABLEWAY.

*We are indebted to the courtesy of "Engineering-Contracting" for the use of the illustrations accompanying this article.

to drive the carriage beyond a certain point, owing to slipping of the driving sheaves. The difficulty is overcome by putting the main cable under a constant tension, causing the carriage to travel approximately along a uniform grade. This may be accomplished by having one end of the main cable fixed, while to the other end, after the cable passes over a sheave, a weight is attached. The disadvantage of this simple device would be the

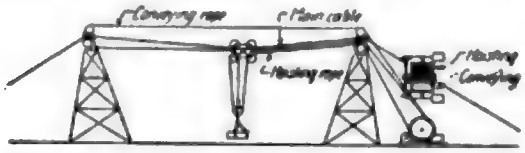


FIG. 2. ARRANGEMENT OF LIDGERWOOD CABLEWAY.

continual bending of the main cable passing over the sheave, while under stress. To bring this bending strain within safe limits would require a sheave so large that its use would be impracticable. The difficulty is overcome by the use of bents, free to move at the top in the direction of the cable. Fig. 1 illustrates the system. It has the trade name of "the Balanced Cable Crane." The electric motor is the most practicable for this system, though it necessitates the paralleling of the main cable with a trolley wire. The fact that the cable must sustain the additional weight of the motor and motorman is a disadvantage, but in many cases it is probably offset by the decided advantage of having the operator close to the loading and unloading, thus minimizing danger and delay.

In cases where the engine or motor is located at the end of the span, at least two ropes in addition to the main cable are necessary—

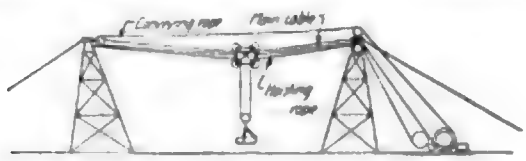


FIG. 3. ARRANGEMENT OF LAMBERT CABLEWAY.

the one for hoisting and the other for conveying. When the orange-peel, clam-shell or other self-filling bucket is employed, a third rope and an extra drum on the engine must be provided.

Arrangement of Hoisting and Conveying Ropes.—Figs. 2, 3 and 4 show three different arrangements of hoisting and conveying ropes which have been adopted by the Lidgerwood Manufacturing Co., the Lambert Hoisting Engine Co. and the Trenton Iron Co. respectively. In the arrangement shown in Fig. 2 the load is first hoisted to the desired height. During conveying, both the hoisting and conveying drums must be in operation, and of the same diameter, so that the load may remain at a constant distance from the cable.

In the arrangement shown in Fig. 3 the engine drums usually have different diameters, the larger being the conveying drum. This arrangement permits simultaneous hoisting and conveying, and a conveying speed greater than hoisting speed. A somewhat larger engine is necessary owing to the two-part hoist, instead of three-part, as in the other arrangement.

The arrangement in Fig. 4 was devised to obviate the necessity of using carriers to prevent sagging of hoisting rope. The hoisting rope is attached to an endless rope at the point A by means of a specially constructed swivel connection. The endless rope is passed a number of times around an elliptic-faced drum to give sufficient friction for hoisting the load. In operation both hoisting and conveying drums are in motion during conveying, as in Fig. 2, and both must be of the same diameter.

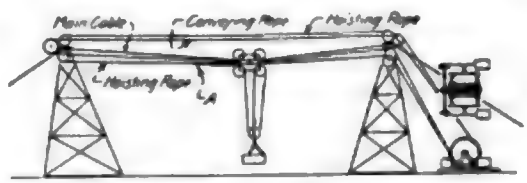


FIG. 4. ARRANGEMENT OF TRENTON IRON CO. CABLEWAY.

Fall-rope Carriers.—The economical operation of a cableway depends in no small measure upon the carriers employed. Their function is to prevent excessive tension (due to sag) in the hoisting rope, so that when the load is detached from the fall-block the latter, while free, will not ascend to the carriage. Even with the use of carriers it is necessary to use a weighted fall-block, so that it may be raised or lowered by the engineer when no load is attached.

The following are styles of carriers which are in use:

(1) Chain-connected Carriers.—These consist of a supporting sheave which travels upon the main cable, below which in the same frame are sheaves for the support of other necessary ropes. The side plates which form the frame for the sheaves must project beyond them, so that when adjacent carriers strike each other the sheaves will not come into contact. The

connected carriers are attached at one end to the tower and at the other to the carriage. When the carriage is close to the head tower (engine end), the carriers are all in contact with the chains hanging in loops below. As the carriage moves toward the tail tower the carriers are spaced along the cable with the chains hanging in festoons below.

(2) Button-rope Carriers.—With this carrier an additional rope across the span is required. It is fixed at one end and kept at a constant tension by a weight at the other. At intervals along the rope are affixed "buttons" with a gradation of diameters, the smallest being the first from the head tower. The carriers are provided with eyes having a corresponding gradation of diameters, slightly smaller than the buttons, through which the button rope is threaded. The carriage is provided with a projecting arm or "horn," which picks up the carriers as each is met during the travel of carriage toward the head tower. All the carriers are riding upon the arm when the head tower is reached. On moving away from the head tower, the first button passes through the eyes of all the carriers but the last. This one is snatched from the arm and deposited upon the cable. The second button selects the next carrier, and so on.

(3) The Lambert-Delaney Carrier.—This is rather an ingenious device, depending upon the fact that points along the vertical diameter of a horizontally rolling wheel travel at different velocities. The rolling wheel in the case of the carrier is inverted, and rolls upon the under side of the main cable. The conveying rope is the rolling force, and is applied at different distances from the center of the rolling sheave to obtain the required variation in velocity of travel. Fig. 5 illustrates the construction. It will be noticed that in the quarter-speed carrier a yoke with set screw is used to increase the friction between the rolling sheave and cable.

The advantages and disadvantages of the above types of carriers are as follows:

Chain-connected Carriers.—Advantages: (a) Simplicity. (b) Not easily deranged. (c) Positive spacing. Disadvantages: (a) Extremely heavy. (b) Considerable wear. (c) Power required to stretch chains as carriage nears tail tower.

Button-rope Carriers.—Advantages: (a) Extremely light. (b) Minimum wear to both carrier and cable. (c) Positive spacing. Disadvantages: (a) Maintenance of button rope.

Lambert-Delaney Carriers. — Advantages: (a) Neither rope nor chains required for spacing. (b) Weight of carriers uniformly distributed at all times between carriage and towers. (c) Moderate weight. Disadvantages: (a) Double bending of conveying rope while passing through carriers, causing short life of rope. (b) Variable spacing due to slip between rolling sheaves and cable. (c) Large number of sheaves to maintain.

The arrangement shown in Fig. 4 is "the Laurent-Cherry" system, which employs no carriers, as above mentioned. The advantages are: (a) A minimum of working parts not easily accessible. (b) A minimum of dead weight to be sustained by cable. The disadvantages are: (a) The endless hoisting rope is subject to considerable wear owing to constant slipping on elliptic-faced drum. (b) When hoisting from a considerable depth below the main cable and conveying toward the tail tower there is a limit to the distance of approach to the tail tower, owing to the fact that connection at A, Fig. 4, cannot pass over

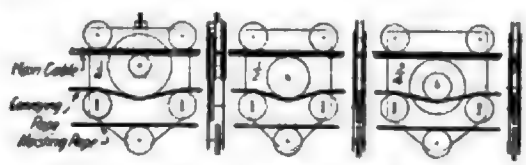


FIG. 5. LAMBERT-DELANEY CARRIER.

the tail tower sheave. On this account a greater span is necessary under such conditions than in the other arrangements.

Relation Between Size of Engine and Inclination of Cable.—As previously stated, the path which the carriage travels when both ends of the cable are fixed is approximately an ellipse (catenary between carriage and towers neglected). When it is necessary, therefore, to convey the load close to either end of the span, the inclination must be taken into consideration.

In the Lidgerwood and Laurent-Cherry systems, where the diameters of hoisting and conveying drums must be the same, the size of the engine is determined by the load to be hoisted, provided the inclination of the cable does not exceed 22° (19½° with friction neglected). Beyond this inclination the power required for conveying is greater than that for hoisting, and is proportional to the sine of the angle of inclination.

In the Lambert system, where a two-part line is used for hoisting, and where there may be any desirable ratio between the diameters of conveying and hoisting drums, the inclination of the cable at which equal power is required for hoisting and conveying is about 32°

(30° neglecting friction). With inclination less than 32° the conveying drum may be larger than the hoisting drum, and for a cableway which is nearly horizontal the engine is provided with a conveying drum about twice the diameter of the hoisting drum. In all cases the ratio of gearing is the same for both drums.

THE INCLINE CABLEWAY.

It is obvious that when the inclination of the cable is such that greater power is required for conveying than for hoisting, the carriage will remain stationary on the cable while the load is being hoisted, even though no conveying or endless rope is used. Should the load be hoisted until the fall-block comes into contact with the carriage, the further pull on the hoisting rope will cause the carriage with the load to move along the cable. A single drum engine is, therefore, all that is necessary.

The simplest form of incline cableway is used where the loading is always done at the same point, also the unloading. In this case a stopping block is clamped to the main cable to prevent the carriage running below the point of loading, and a self-engaging latch is clamped to the cable at the unloading point to hold the carriage in position while the load is being lowered for unloading.

Where it is necessary to provide means for loading and unloading at any point, an endless rope is used as in the horizontal cableway, but no power is necessary for its operation, its function being merely to hold the carriage at any desired point. This is accomplished by passing the endless rope a number of times around an elliptic-faced drum provided with brake only.

The Aerial Dump.—The scope of the cableway is largely increased by the possibility of dumping the contents of the skip at any point in its travel by the manipulation of a lever at the engine. The skip employed has an open end, so that tilting is all that is necessary for dumping. The skip is suspended from the hook of the fall-block by chains with hook ends attached to the sides and ends of the skip. The end of the skip is also attached to another fall-block reeved with the dump line. The latter necessitates two additional sheaves below the cable in the carriage and is reeved in a manner similar to the hoisting rope. In the Lidgerwood self-dumping device the dump line is wound on the hoisting drum, and when it is desired to dump the skip, the line is shifted by a suitable mechanism upon an increased diameter of drum, which is provided for the purpose. This causes the dump line to be drawn in at a higher rate of speed than the hoisting rope, and results in the tilting of the skip for discharging the contents.

In the Lambert system the dump line is attached to its own drum mounted on a shaft with hoisting drum, in close contact with the latter and so arranged that the hoisting drum, when released with a load, can make only a half revolution while the dump line drum is stationary. During hoisting, the hoisting drum drives the dump line drum and, both being of the same diameter, the skip remains horizontal. When it is desired to dump the skip, the brake is applied to the dump line drum and released on the hoisting drum.

The Lambert Company has also installed a dumping arrangement for dumping the load close to the towers. It consists of a long hook suspended from a third main cable sheave on the carriage. Owing to the difference in inclination of the cable at the center and ends of the span, the hook, which always hangs vertically, is closer to the skip at the desired end than at other points along the cable. On lowering at the dumping point, the hook engages the bail at the end of the skip. The practicability of this arrangement is doubtful when it is desired to dump the load at the tail tower end. The skip swings more or less when the carriage is stopped, and the engineer, being unable to observe the oscillations, is likely to lower the skip when it is swung away from the hook.

Lubrication.—The fact that the sheaves in the carriers, carriage, and tops of towers are not easily accessible renders self-lubricating bushings desirable, and they are generally used. Their use, however, does not mean that little attention is required. The carriage and hoisting rope especially should be carefully examined daily, for, while the apparatus is seldom used to transport men, the load is generally conveyed above them.

Towers.—Either tower may be fixed or movable. When both are movable the tracks must either be parallel or lie in the same circle. The parallel track arrangement was used extensively in the excavating of the Chicago Drainage Canal. Movable towers diametrically opposite on circular tracks have never been used so far as the writer is aware. A common arrangement, however, is the radial cableway, where one tower is fixed and the other movable.

Movable towers are mounted on standard railroad wheels. The track consists of six or seven lines of rails, and rail braces should be

used plentifully. Power for moving the tower may be obtained from the winch head on the cableway engine, or, if the tower must be moved often, a special engine is provided. Movement is accomplished by block and tackle between the engine and anchorage at either end of the track. Considerable power is necessary on account of the large amount of friction between flanges of wheels and rails.

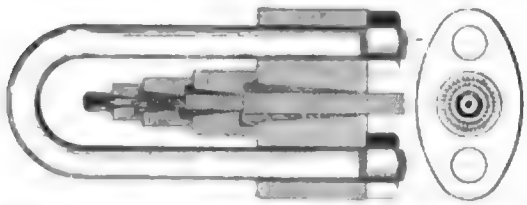


FIG. 6. STEP SOCKET FOR MAIN CABLE.

For low towers in fixed positions the "A"-frame is commonly used, but the head tower should not be so low, or the engine so close to it, that the fleet angle of the ropes becomes excessive. In some cases, especially in incline cableways, the tail tower may be dispensed with and a rock anchorage substituted. High towers are common where height is desired for disposal of material beneath the cable, and in very low spans where the deflection of the cable is necessarily large. They are usually constructed of wood, for the reason that the cost is less and in most cases they will last as long as the cableway is required. The base of the tower is usually from one-third to one-half the height. Steel masts are sometimes used for tail towers. They require at least three strong and well anchored guy lines. The base has a ball and socket joint of steel castings, and the customary wood saddle is bolted to the top for the main cable.

Main Cable.—The essential features of the main cable are strength, lightness, flexibility, and a surface which will not only receive the least wear but impart the least wear to the sheaves rolling upon it. The standard hoisting rope is objectionable from the standpoint last mentioned. Though less flexible than the hoisting rope, the locked-wire rope is generally used for the reason that the other qualities are possessed to a much greater degree.

Fig. 6 shows the socket used on the locked-wire rope. There are six wedge segments in each cone, with the exception of the smallest, which contains four.

Means are provided for taking up the main cable when the deflection has become excessive, due to stretching. In short spans a turnbuckle is inserted in the sling which passes around the anchorage and thence through a sheave attached to the end of the cable. For long spans, special double or triple sheave blocks are used, reeved with wire rope. The take-up is usually located at the head tower end so that the engine may be utilized when taking up is necessary.

Anchorages.—The tension of the main cable is usually from five to six times the load, depending upon the deflection. Anchorages secure beyond all possible doubt, are essential, as their failure would prove disastrous to the cableway and imperil the lives of men. Since it is impossible to calculate the resistance offered by the earth to a buried anchorage, it is usual to find a much stronger anchorage than is necessary. The usual form for moderate tensions—say up to 30 tons—is a well tarred oak log about 18 ins. in diameter and 16 ft. long, buried to a depth of 8 or 10 ft. If longer life is desired, or if the tension is

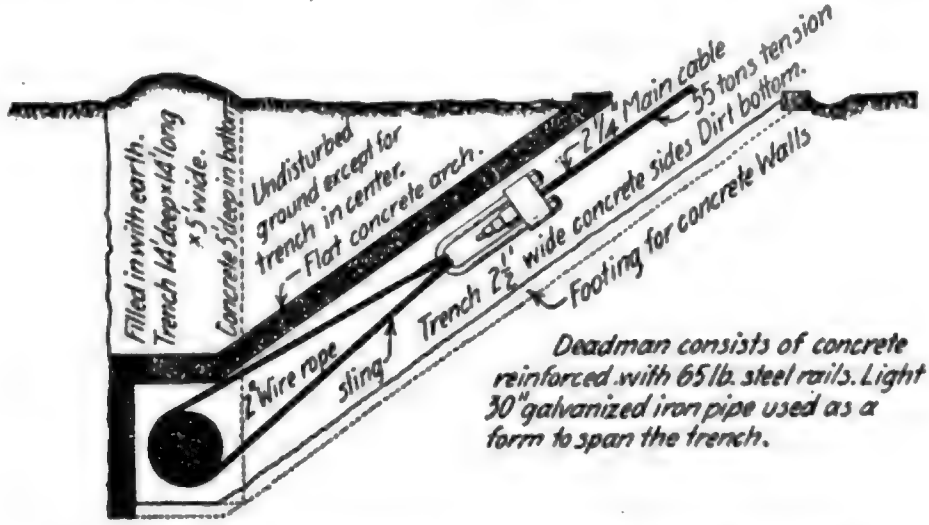


FIG. 7. CONCRETE ANCHORAGE FOR MAIN CABLE.

greater, a concrete anchorage may be substituted. A form which has been successfully used is shown in Fig. 7.

Formulas.—The following are the formulas generally used when the cable is approximately horizontal:

In Fig. 8 let w = weight of cable per foot,

t = tension in pounds at tower,

d = deflection of cable in feet at any point, x, distant n feet from tower B and m feet from tower A.

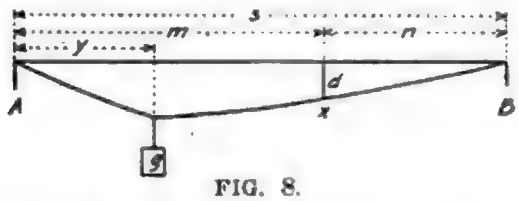


FIG. 8.

s = length of span = m + n,

g = weight of carriage, skip and load (or concentrated load) in pounds, distant y from tower A.

Deflection at x due to cable alone

$$d = m\,n\,w \div 2\,t \quad \ldots\ldots (1)$$

Deflection at center due to cable alone

$$d = w\,s^2 \div 8\,t \quad \ldots\ldots (2)$$

Deflection at x due to concentrated load alone

$$d = g\,n\,y \div s\,t \quad \ldots\ldots (3)$$

Deflection at center of span due to load alone

$$d = g\,y \div 2\,t \quad \ldots\ldots (4)$$

If y = s/2, equations (3) and (4) become respectively

$$d = g\,n \div 2\,t \quad \ldots\ldots (3')$$

and $$d = g\,s \div 4\,t \quad \ldots\ldots (4')$$

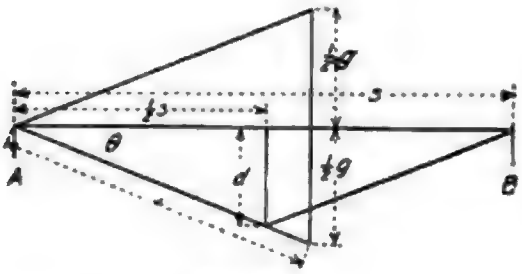


FIG. 9.

Deflection due to both cable and concentrated load is obtained by adding the separate deflections. Therefore for total deflection at x

$$d = (wmns + 2\,gny) \div 2\,s\,t \quad \ldots\ldots (5)$$

Or at center of span

$$d = (ws^2 + 4\,gy) \div 8\,t \quad \ldots\ldots (6)$$

If y = s/2, (5) becomes

$$d = (wmn + gn) \div 2\,t \quad \ldots\ldots (5')$$

and (6), $$d = (w\,s^2 + 2\,gs) \div 8\,t \quad \ldots\ldots (6')$$

If y = m, (5) becomes

$$d = (wmns + 2\,gmn) \div 2\,s\,t \quad \ldots\ldots (5'')$$

and (6) becomes

$$d = (ws^2 + 4\,gm) \div 8\,t \quad \ldots\ldots (6'')$$

Fig. 9 shows a graphical solution for a concentrated load in the center of the span. We may note the following:

$$\text{Tan } \theta = 2\,d/s,$$

$$\text{Sin } \theta = g/2\,t.$$

Since for small angles (figure is exaggerated), the tangent and sine are nearly equal,

$$2\,d/s = g/2\,t,$$

or

$$d = g\,s/4\,t, \text{ which is equation } (4').$$

Substituting ws/2 for g,

$$d = ws^2/8\,t, \text{ which is equation } (2).$$

We see, therefore, that instead of a uniform load of the rope in the catenary curve it may be assumed as a concentrated load equal to one-half the uniform load.

Fig. 10 shows a graphical solution for the load at any point distant y from tower A. We may note the following:

$$\text{Tan } \theta = a/y,$$

$$\text{Sin } \theta = k/t;$$

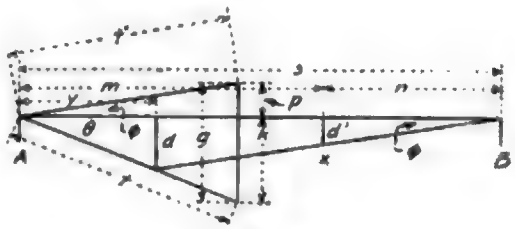


FIG. 10.

Therefore

$$d/y = k/t, \text{ approximately.}$$

$$\text{or } k = dt/y.$$

$$\text{Tan } \theta = d \div (s - y)$$

$$\text{Sin } \theta = p/t' \text{ or } p/t, \text{ nearly.}$$

Therefore

$$d \div (s - y) = p/t,$$

$$\text{or } p = d\,t \div (s - y),$$

$$\text{and } k + p = g = (d\,t/y) + [d\,t \div (s - y)]$$

or $$gy\,(s - y) = dt\,(y + s - y)$$

$$\text{or } d = g\,y\,(s - y) \div s\,t.$$

Since $$d : d' = (s - y) : n$$

$$d' = dn \div (s - y)$$

$$\text{or } d' = g\,y\,(s - y)\,n \div s\,t\,(s - y)$$

$$= g\,y\,n \div s\,t,$$

which is equation (3).

Substituting ws/2 for g and m for y, which are the conditions obtaining when deflection at any point due to rope alone is considered,

$$d' = m\,n\,w \div 2\,t, \text{ which is equation } (1).$$

It has been shown that the formulas given above involve the assumption that the tangent and sine of small angles are equal. In the graphical analysis this is unnecessary. It is obvious, therefore, that a graphical solution

drawn carefully to a fairly large scale will give closer results than are obtainable from the formulas.

Fig. 11 is a graphical analysis of stresses in the cable and towers of a 953-ft. cableway. It is desired to hoist and convey a load of 10 tons (including skip, fall-block and carriage). Using formula (6′) and assuming a 2-in. locked-wire rope (w = 10 lbs.) with a deflection of 50 ft. (about 5% of span) we find a tension of 58 tons. Since the working load of the 2-in. locked-wire rope is only 43 tons we now see that at least a 2¼-in. locked-wire rope with a working load of 55 tons should be used. The weight of the 2¼-in. rope is 12⅓ lbs. to the foot or about 6 tons for the 953-ft. span. In the graphical solution, we therefore assume a center concentrated load of 10 + 6/2 or 13 tons. Triangle OHK is the force polygon for a deflection of 40 ft. at the center, which gives a tension of 77.3 tons. Tensions for various deflections from 40 ft. up to 100 ft. with 10-ft. intervals are shown to range from 77.3 to 31.2 tons. A line drawn from O intersecting the 13-ton line AFH so that OF is 55 tons, the proper working tension, indicates a proper working deflection at the center of 56.5 ft.

Should it be found necessary at any time to subject the cableway to a load greater than given above, the proper deflection to correspond with the allowable tension of 55 tons is found by drawing an arc with center at O and radius OF (55 tons) to intersect OA, OB, etc., produced; scaling the distance between the respective intersections and the line OP, and multiplying by 2 will give the respective safe loads (the distance scaled in each case is only one-half the side of an incomplete force polygon). Care must be taken, however, that the hoisting and conveying ropes are sufficiently strong for the increased load.

Comparison of Analytical and Graphical Solutions.—Solving formula (6′) for a deflection of 50 ft., the tension is found to be 61.27 tons; graphical method gives 61.5 tons.

The main advantage of the graphical method is that a glance of the diagram will show the proper deflection for any load. OXV represents a traveling tower at one end of the span. The cable is fastened to the tower at X, and V is the point about which the tower tends to rotate, due to the tension of cable. The polygon UJWY shows that a force Y-U of 46.2 tons applied vertically at X is necessary to obtain equilibrium of the tower. The moment of this force about V is 46.2 × 43.5 = 2,009.7 foot-tons, and counter-moments of an equal amount must be applied in the shape of ballast, engine, boiler, or other form. The weight of cableway and tower supplies the safety factor.

The front posts of the traveling tower lie in the line of the resultant of the main cable. They should have sufficient strength to sustain

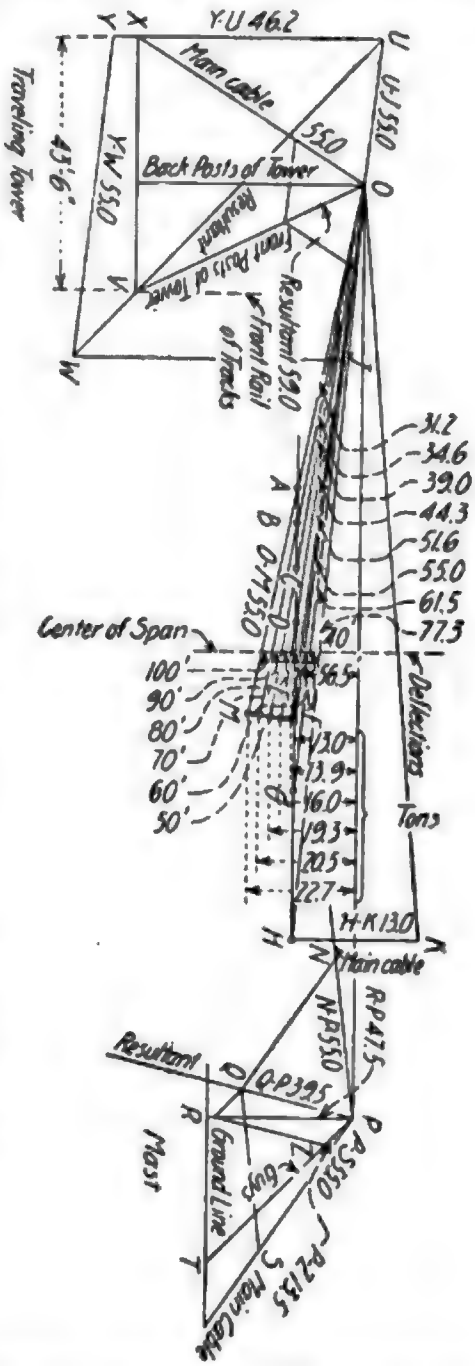


FIG. 11. STRAIN-STRESS DIAGRAM FOR GRAPHICAL ANALYSIS OF CABLEWAY.

the resultant force of 59 tons. Although the back posts in reality sustain a part of this force, it is well to assume that they take only the vertical load of one-half the cable and the other ropes, plus loaded skips. They are usually of the same size as the front posts.

A steel mast is used for a tail tower and the

polygon NPQ shows a main cable resultant force of 39.5 tons. The polygon PRZ shows that the mast must sustain a load of 47.5 tons, while the guy line PT must have a tension of 13.5 tons. Only one guy line is shown, but there are four, two extending behind with an included angle of about 60° and two in front with an included angle of about 120°. The front guys are intended to take the side pull when the traveling tower is not in line with mast and anchorage at the mast end. They have not been shown on diagram owing to complexity which would arise were resolutions of forces in a horizontal plane added.

THE DUPLEX PROCESS FOR STEEL MAKING

By PROF. HENRY M. HOWE

CONDENSED FROM "ELECTROCHEMICAL AND METALLURGICAL INDUSTRY"

The advantage of the duplex process whereby it compensates for its disadvantage of complexity is that it simplifies the conditions with which the composition of the pig iron has to comply, and thus lessens the danger of making iron unsuited in composition to the process for which it was intended.

The duplex process removes the silicon and part of the carbon of the pig iron in an acid Bessemer converter, and then removes the phosphorous and brings the steel accurately to the desired composition and temperature in a basic open-hearth furnace to which the molten metal is transferred. How does this simplify the conditions with which the composition of the pig iron must comply? Pig iron for the acid Bessemer process must be low in sulphur, and its silicon content should be nearly constant, while that for the basic open-hearth process should be as free as possible from silicon and sulphur. These limitations are very difficult to comply with, because most of the conditions in the blast furnace which tend to restrict the sulphur-content tend to raise the silicon-content. By relieving the blast furnace manager of these limitations the duplex process may be of service.

The reason why the sulphur-content of the pig iron for the acid Bessemer process should be small is that this process removes none of this impurity. The reason why the silicon-content should be nearly constant is, first, that it is essential to the making of sound steel that the temperature at which the molten steel is cast should be exactly that aimed at; and, second, that variations in the silicon-content tend to cause variations in the temperature of the process, for the reason that the combustion of silicon is the chief source of heat. It is true that the variations in silicon are greatly lessened by the use of the "mixer," and that the means of counteracting them are fairly effective. But, though the harm which they do is thus lessened, it is not wholly done away with. If, as in the duplex process, the Bessemer converter is relieved of the work of bringing the steel to the needed casting temperature, and has only to remove the bulk of the silicon and carbon without reference to the temperature, the silicon-content of the pig iron becomes relatively unimportant as regards the Bessemer end of the process.

The reason why the silicon-content should be small in pig iron for the basic open-hearth process is that the silica which results from the oxidation of the silicon corrodes the basic lining of the furnace, and by lessening the basicity of the slag, interferes with the removal of phosphorus and sulphur. The reason why the sulphur-content should be small is that the work of removing sulphur is slow and costly. But if the silicon of the pig iron is removed by a preliminary treatment in a Bessemer converter, then the silicon-content of the pig iron from the blast furnace is a matter of indifference as regards the open-hearth end of the process, and we have already seen that it becomes of only minor importance for the Bessemer end.

With the silicon-content of the pig iron thus

made relatively unimportant, the work of desulphurizing in the blast furnace becomes easier and more thorough, because it is freed from the need of simultaneously controlling the silicon-content.

If we look at the matter from the point of view of the open-hearth process, the preliminary desilicizing in the Bessemer converter may prove profitable; but whether it will prove more profitable than desilicizing in a regeneratively heated mixer remains to be proved. We naturally conjecture that, if there is but a moderate tendency to excessive silicon-content the mixer treatment should be more profitable, because it would imply less loss of iron than the preliminary Bessemerizing. But if the silicon-content is likely to be excessive, the Bessermerizing should be better, because it should remove the excess of silicon more easily than the mixer.

THE USE OF BALL BEARINGS ON ELECTRIC MOTORS

CONDENSED FROM "THE ELECTRICAL REVIEW," LONDON

Although there are now many reliable ball bearings on the market, they do not seem to be made use of on electric motors to the extent that one would expect when one considers the many advantages to be gained by their use. The principal advantages are as follows:

1. Decreased Length of Machine.—Ball bearings are usually less than one diameter (of shaft) long, while ordinary bearing brasses are either two and a half, or in most cases, three diameters long, and for this reason the overall length of the machine can be decreased, and consequently a somewhat lighter machine per horse-power can be manufactured.

2. No Wear on Bearings.—Owing to the accuracy to which the balls can now be made, and the races can be machined and to the hardness of the balls and races, there is practically no wear in these bearings.

For this reason, these bearings seem to be the ideal bearing for hand-wound closed-slot induction motors, where the air-gap is often cut down as fine as 0.025 in.

3. No Oil in Bearings.—Ball bearings should be filled with grease, and they will then run for months without any attention, whereas, with an ordinary bearing using oil lubrication, the bearings have to be inspected at frequent intervals to see that the oil is up to the proper level for the oil rings to pick up the oil. Moreover, there is always present the trouble of oil creeping along the shaft into the armature.

4. Less Starting Resistance.—Owing to the very small frictional losses the resistance to starting up of a machine fitted with ball bearings is much less than in a machine fitted with ordinary bearings, and consequently the current required to start up is less. The coefficient of friction, unlike that of ordinary bearings, is not higher at starting than when running at the working speed.

5. Increased Efficiency.—Owing to the friction in ball bearings being very small, a machine fitted with them will give a better efficiency than one fitted with the ordinary bearings, and as an increase of efficiency of only 1 per cent. means a good deal when a machine is in constant use, this is rather an important advantage.

The coefficient of friction for a continuously lubricated bearing is about 0.05, while for a ball bearing it is 0.0012 to 0.0018, and this is not affected to any extent by the size of the balls or the number of revolutions per minute.

Ball bearings have been applied with great success to dynamos, grinding and wood-working machinery, all of which run at high speed. Machines fitted with them have been running satisfactorily for years at 10,000 to 12,000 r.p.m., and the same may be said of line shafting 4 ins. to 6 ins. diameter, and running at 500 to 1,200 r.p.m. Furthermore, these bearings have been fitted to ventilating fans of up to 15 tons weight, and a periphery speed of 330 ft. per second.

Too great stress cannot be laid upon the importance of having the balls absolutely correct to standard both in diameter and sphericity (within one ten-thousandth of an inch), as with hard steel balls running between hard steel races it is of vital importance that the load should be equally distributed.

The races should be grooved and the curvature of the groove should represent the arc of a circle somewhat larger than that of the balls.

Too much importance is often attached to the crushing load, which is apt to be misleading, because although a ball will not absolutely

crush to pieces until this load is reached, it will, if the pressure is released at about half the ultimate crushing load, be found that the ball is in two pieces. However, with regard to the crushing strength of balls, it may be said, that all things being equal, it increases proportionately as the square of the diameter.

With regard to the safe load on balls: from tests made at the "Central Institute for Technical Investigation" at New Babelsbery, the safe load for balls running on rounded surfaces = 44 d^2 when d = diameter of ball in eighths of an inch; for plain or conical surfaces the load must be smaller, and should not exceed about one-fifth the formula value.

It should be borne in mind that the permissible load is related to the speed at which the bearings run, and as the number of revolutions per minute is increased so must the load be reduced.

The following table gives dimensions and safe loads at various speeds for same:

Shaft diam. in ins.	Ball diam. in ins.	No. of balls.	—Safe Load in Lbs.— 500 r.p.m	1,000 r.p.m.	2,000 r.p.m.	4,000 r.p.m.
1	⅜	8	900	720	575	450
1½	9/16	8	1,700	1,360	1,090	850
2	⅝	9	2,500	2,000	1,600	1,250
2½	¾	9	3,500	2,800	2,240	1,750
3	1	9	5,000	4,000	3,200	2,500

HEAT STRESSES AND THE FORMATION OF CRACKS

By CARL SULZER

CONDENSED FROM "THE BOILER MAKER"

The question of the formation of cracks in iron and steel by heat stresses has been widely discussed, especially in the case of steam boiler construction. There is frequently doubt concerning the nature of the origin and the action of such stresses and concerning the true reason for the formation of the cracks. Lacking any other satisfactory explanation one is inclined to ascribe the cause of such occurrences either to the material and its chemical composition or to the design of the boiler, or perhaps to its construction. One or the other of these reasons enters into a great many cases in a greater or less degree, but it is certain that cracks have formed where no known reason will suffice for an explanation, where material has failed, which fulfills all specifications, where the design of the boiler is above criticism and where its construction has been proved excellent.

The object of this article is to describe one such case which offers a striking example of the formation of cracks by heat stresses, and for this reason it is necessary to try to explain more fully the action of such stresses. For this purpose a well-known case of crack formation as it occurs in cast iron might be briefly mentioned.

Let us consider the conditions during the casting of a double-walled cylinder. It frequently happens that while the casting is cooling, the outer part of the mold is destroyed and the outer wall of the casting left partially uncovered, while the inner core has not been removed. The outer wall is thus cooled much more quickly than the inner one. This cooling of the outer wall causes a certain decrease in the length. Since the inner wall is still in a moldable condition it offers no satisfactory resistance to the premature shortening of the length. On account of its connection at both ends with the outer wall it is forced, during the remaining time the metal is contracting, to withstand a compressive stress which may exceed the elastic limit of the material. After the temperature of the outer wall approaches that of the atmosphere, the wall gradually forms a rigid frame, within which the inner wall, which is still hot, must cool and contract. Therefore, longitudinal stresses are set up in the latter, which, under certain conditions, may cause a fracture or circumferential cracks in the inner cylinder.

The formation of the cracks begins as soon as the linear contraction within fixed points is equal to, or greater, than the ductility of the metal. The linear expansion of cast iron, due to a difference of temperature of 180° F., is usually assumed to be .001 of its length. On the other hand, the breaking elongation, assuming a modulus of elasticity of 14,220,000 lbs. and a mean tensile strength of about 21,-

300 lbs. per sq. in., and also assuming that the elongation is proportional up to the breaking point, is about .0015 of the length of the bar. Therefore, it is evident that in the case of cast iron, a fracture will occur with a decrease of temperature of about 270° F.

To prove this statement, the following experiment may be performed. Heat a bar of cast iron, preferably in an oil bath, to about 360° F., and place it in a rigid frame, with its ends fixed in position and entirely free from stress. The bar will break after it has cooled so that its temperature has dropped from about 360° to about 90°. To avoid these harmful stresses, especially in large-sized steam cylinders, it is customary to construct the outer shell and the inner working cylinder separately and afterwards join them together by shrinking. Since the working cylinder is in contact with steam on both sides, it rises to a higher temperature than the outer shell, and so its connection to the outer shell must be such that it is free to expand in a longitudinal direction. In cases where this is not done, where the connection is rigid at both ends, cracks are formed, due to the repeated thrusts of the inner cylinder. Also inaccurate measurements in allowing for the shrinking operation are liable to cause the addition of longitudinal cracks in the outside shell.

While cracks in cast iron, due to the conditions just stated, can usually be quickly seen, this is not the case with the tougher mild steel. There such cracks are only formed gradually, and frequently repeated action of these destructive stresses is necessary until finally the flexible material gives way.

The writer investigated a typical case of this kind, where a fire-tube boiler failed. This boiler has been forced far beyond its normal capacity for a long time. Cracks appeared in the boiler plate which were not due to tensile stresses due to steam pressure. Assuming a difference in temperature of between 360° and 720° F., an elastic limit for the material for tension and compression of 22,000 lbs. per sq. in. and a modulus of elasticity of 28,400,000 lbs., the expansion will amount to 0.00075 of the length. The sum of the expansion and contraction (0.0015 of the length) is equal to the linear expansion due to the difference in temperature. Since the coefficient of expansion of mild steel for the difference in temperature, 180° F., amounts to about 0.0015 of the length, therefore when the difference in temperature reaches 180° F., the boiler plates are stressed beyond their elastic limit for tension or compression. A higher difference in temperature causes a corresponding excess over the elastic limit and a frequent repetition of this occurrence, without doubt, leads to the gradual formation of cracks.

The question arises whether steel makers cannot produce boiler plate which will better withstand such an excessive strain. The foregoing facts show that a better material in the sense of being better able to resist such stresses should have a higher elastic limit or smaller modulus of elasticity. A decrease in the modulus of elasticity is equivalent to decreasing the tensile strength of a material which has a certain ductility or percentage elongation.—Translated from the "Zeitschrift des Vereines Deutscher Ingenieure."

AN ELECTRICAL THERMOMETER FOR MEASURING GAS-ENGINE TEMPERATURES

Professors H. L. Callendar and W. E. Dalby described in a paper recently read before the Royal Society a form of platinum thermometer which measures directly the temperature of the gas in the cylinder of a gas engine at some one point of the cycle. In order to avoid uncertain corrections, it is necessary in any attempt on this problem to employ wires fine enough to follow the changes of temperature of the gas very closely during suction and compression. If such a wire be employed under working conditions, it must be perfectly screened from the flame during explosion. The arrangement designed by the authors is such as to introduce the thermometer into, and withdraw it from, the cylinder at the proper instants, and to do this without making any change in the usual form and extent of the clearance surface during the time interval comprising the end of compression. The thermometer itself consisted of a loop of platinum wire 0.001 inch in diameter and 1 inch long, and a compensation loop of similar wire was provided to eliminate the end effects arising from conduction to the leads. The current employed in measuring the change of resistance (which was practically 1 ohm for 100° C. rise) was about 1/200 ampere. This ther-

mometric arrangement was contained in a small valve inserted through the spindle of the admission valve, which was bored out to receive it. This thermometer valve was introduced into the cylinder by a cam operated by a simple gear. In order to measure the temperature at a definite point of the cycle, a periodic contact-maker was inserted in the testing battery circuit. This consisted of two cams on the same axle and two brushes. The shape of each cam was a flat spiral, which lifted the corresponding springy brush away from the axis as the shaft rotated, and the spirals each terminated with a step which allowed the brushes to fall suddenly. The steps were staggered in angle, so that the brushes fell at different instants. As one side of the electrical contact was carried by one brush, and the other side of the contact by a projection on the second brush, by setting the cams initially at the proper angle, any desired period of contact could be brought about at any desired point of the gas-engine cycle. This method has the advantage that it can be applied without difficulty to any existing engine by simply making a special admission valve. It is absolutely necessary in such investigations that the engine should repeat a perfectly regular cycle at each explosion. No results of any value can be obtained with a hit-and-miss governor in operation, because the conditions vary too greatly from stroke to stroke.

THE ADVANTAGES OF PRODUCER GAS-FIRING

The use of producer gas, in place of direct firing with coal, presents the following advantages:

Even with the lowest grades of bituminous fuels a complete and practically smokeless combustion is obtained.

The temperature is easily regulated and kept constant and the waste heat of the products of combustion can be utilized for preheating the combustion air or the gas, whereby a considerable saving in fuel is effected.

A slight excess of either air or gas can be used, if so desired, for obtaining an oxidizing or reducing flame, which is of special importance to the chemical industries.

The material to be heated does not come in contact with the solid fuel or ashes. Hence, for instance, in using gas in a limekiln, a purer product will be obtained than with direct firing. In using producer gas under a boiler the life of the latter will be prolonged on account of the purity and uniformity of the flame.

Less skill is required for taking care of a gas-fired installation than of a direct fire.

Producer gas-firing is especially adapted for central stations, as the gas produced in one producer, or in a battery of producers, can be distributed through pipes to a large number of furnaces.

Reverberatory furnaces are widely used in the industries for melting, glowing, roasting and various chemical and metallurgical operations. Most of these furnaces, however, are at present still heated by direct firing, causing a great waste of fuel.

By providing such furnaces with producer gas-firing, a saving of 30% in fuel is effected.

The manufacture of cement affords the occasion of generating high temperatures without complicated preheating apparatus, as in this kind of work the large amount of sensible heat of the incandescent clinker can be successfully used for preheating the air up to 800-810° F. The air (of 800° F.), coming in contact with the hot gas as it leaves the producer, combines with the latter, generating a temperature of 2,070° F., the same temperature as is obtained by coal dust firing. At this temperature the reaction of the cement formation is starting, generating heat and increasing the temperature to 2,700° F. The advantages of producer gas for cement kilns as compared to coal dust firing are: doing away with the expensive coal-pulverizing plant, cleaner finished product and 25% saving.—Dr. Oskar Nagel, in "Cassier's Magazine."

THE DESIGN OF STRUTS

By W. E. LILLY, M. A., M. A. I., D. Sc.

CONDENSED FROM "ENGINEERING"

The failure of the lower-chord members of the anchor arm in the Quebec Bridge disaster has drawn the attention of engineers prominently to the question of the strength of struts, and the present time may be considered opportune for examining the principles underlying their design.

The problem involved in the design of a strut is usually—given a certain load and length—to determine its cross-section. Now the cross-section involves its area and the radius of gyration, and thus, indirectly, of its figure or shape, and the thickness. It is strange that among the many writers on struts but little information is given as to the relative advantages of different figures or shapes of the cross-section, and scarcely any reference is made as to what the economic proportions of the thickness to the radius of gyration of the cross-section should be.

The formulas in general use do not take into consideration the ratio to be adopted between these quantities. Whether the cross-section of the strut be solid, or of large diameter and small thickness, the same formulas are supposed to hold true in estimating its strength, and it is due rather to the eye of the designer, than to reasoning based on theory, that the proportions in common use have been arrived at; or, in other words, the designer assumes empirically some values which seem most suitable under the circumstances.

Considered from the theoretical point of view, there is for every strut of given length and load a definite area and radius of gyration, and thus, indirectly, a definite thickness, for the most economical cross-section, and any departure from these proportions involves waste of material.

For instance, take the case of a hollow mild-steel strut of circular cross-section; if the diameter is great, and the thickness small, the strut fails by wrinkling of the sides or by secondary flexure; if the diameter is small and the thickness great, it fails by primary flexure, or bending; hence it follows that for some particular diameter and thickness it will fail equally by secondary or primary flexure. A column, in which the length, diameter, and thickness are so proportioned as to obtain this result, is called an economic column, and the load it will carry for a given quantity of material is a maximum.

During the past three years experiments have been carried out in the engineering laboratory of Trinity College, Dublin, with a view of determining experimentally the conditions under which failure takes place in a strut either by primary or secondary flexure, and thus indirectly to obtain some definite information of the best ratios of diameter to thickness to be adopted. A detailed description of the experiments, together with a proposed modified formula for struts, was published in the Procedings of the Institution of Mechanical Engineers, 1905, and of the Institution of Civil Engineers of Ireland, 1906. It was then shown that some remarkable wave phenomena occur in connection with secondary flexure, and subsequently that the analysis of the waves admitted of being simply expressed.

From the experiments, and also from the analysis, of these waves it was found that the wave length varied as the square root of the area of the cross-section. This result leads to the following equation for the limiting load:—

$$f = \frac{F}{1 + k \rho t} \quad \ldots\ldots\ldots\ldots (1)$$

where

- f = the limiting load in pounds per square inch on a column of one wave-length.
- F = the strength to compression of the material in pounds per square inch.
- k = a constant = ⅛ for mild steel = 1/10 for wrought iron.
- ρ = the radius of gyration of the circular cross-section of the column about a diameter.
- t = the thickness of the circular cross-section.

For circular sections, which approximate to a solid bar, the value $[(\rho/t) - 0.5]$ should be used for ρ/t ;for the usual sections in practice the 0.5 is negligible.

The above formula with the constants as given applies to circular sections, further experiments on square, triangular, and other symmetrical figures show that the form of the formula is correct, the coefficient k having a particular value for each figure, and the values so far obtained indicate that the value of k is always greater than for the circular sections.

The Rankine-Gordon formula for struts is:

$$p = P/A = \frac{f}{1 \times c\ (l/p)^2} \quad \ldots\ldots\ldots\ldots (2)$$

where

- f = about two-thirds the compressive strength of the material; for wrought iron = 36,000 lbs. per sq. in.
- A = area of the cross-section, in square inches.
- c = 1/9,000 for struts with round ends.
  = 1/36,000 for struts with fixed ends.
- l = length of strut, in inches.
- ρ = radius of gyration, in inches.
- P = total load on strut, in pounds.
- p = load per square inch on struts, in pounds.

From the inspection of this formula it will be noted that the following conditions are supposed to hold true, that the strength of the strut is proportional to its sectional area, the other terms being supposed constant; also that any arbitrary value of ρ can be assumed, and therefore any ratio of ρ/t without affecting the strength of the strut. It will be evident from the investigation on the effect of secondary flexure that these conditions do not hold true, and therefore the formula requires modification in this respect.

Referring back now to equation (1), the value of f has been shown to depend on the deformation due to secondary flexure, and not upon the strength to compression of the material. The arbitrary constant f in the Rankine-Gordon formula thus becomes a variable, and, on substitution of the value obtained for f in equation (1), the following modified formula is obtained:

$$p = \frac{P}{A} = \frac{F}{1 + k\ \rho/t + c\ (l/\rho)^2} \quad \ldots\ldots (3)$$

From a careful comparison of the published tests on solid columns, the value obtained for c is 1/4000 nearly; also from the experiments on secondary flexure, the deduced value of k for mild steel is ⅛.

The failure of the lower chord member of the Quebec Bridge is to be attributed to the bad disposition of the material in the cross-section of the strut. If the same material had been distributed in the form of a stiffened hollow square or a circle, it would have carried the calculated stress with safety, although the factor of safety would have been small.

The published formulas used in designing the compression members of the Quebec Bridge do not in any way take into consideration the figure of the cross-section of these members; and moreover, the forms of the formulas are open to criticism, not being based on the usually-accepted theory of flexure. The values obtained from their use would certainly not agree with those obtained from a large range of experiments; within the ordinary practical ratios of l/ρ from 40 to 80, the values obtained would be fairly approximate, but their use could not with safety be extended beyond these values.

The experimental work on which the views put forward in this article have been based has been mostly carried out on small sections; this has, of necessity, been the case owing to the small size of the testing-machine in the engineering laboratory of Trinity College, Dublin, and the want of a sufficient endowment for carrying on research work. The phenomena accompanying secondary flexure have a very great influence on the economic design of girders, beams, struts, and other engineering structures; and it is to be hoped that money will be found for carrying on research work in this direction.

DEVICE FOR ILLUMINATING HARBORS

CONDENSED FROM "THE ILLUMINATING ENGINEER"

An ingenious device for illuminating harbors and waterways has recently been patented by Mr. L. Dion, of Wilkesbarre, Pa. It consists of a cable, having connected at intervals short branches to which are attached incandescent electric lamps fitted with reflectors which will concentrate the light into parallel beams as nearly as possible and send it upward. The lamp and reflector are made sufficiently buoyant so that they will maintain an upright posi-

DION'S "SUBAQUEOUS" SYSTEM OF HARBOR LIGHTING.

tion. The cable thus equipped is then laid in the proper position in the waterway to be lighted up, and connected with a source of electric supply from shore. The illustration will give a clear idea of the method. The course of the channel will thus be marked out by brilliantly lighted spots on the surface of the water. It is a well-known fact that even the highest waves do not produce any disturbance a very short distance below their own depth. The cable with its connected lamps will therefore always be in practically still water.

The only condition under which this system would seem to be unavailable would be where the water might be turbid. In ocean harbors or roadsteads there is apparently nothing in the way of its successful employment, and this is the view taken by numerous naval and navigation authorities of the highest rank. An important feature of this system is the fact that it offers as good guidance in the densest fog as in perfectly clear weather. Fog and wind practically never occur together, and the beam of light would therefore project from the level surface of the water up through the fog. By the use of a water telescope, which is a tube having an observation glass that can be dropped beneath the surface of the water, or by the provision of a bullseye inserted in the hull of the vessel below the water line, it would be possible to guide the ship without reference to the surface light on the water.

SPECIFICATIONS FOR IRON AND FUEL*

By RICHARD MOLDENKE, Ph. D.

Since the relative proportions of combined and free carbon may in a great measure be controlled through the silicon, it is generally sufficient to specify the maximum allowable percentages of sulphur, phosphorus and manganese.

For ordinary machinery castings (gray iron) the pig iron used as part of the charge should contain:

Sulphur, not more than.....0.05%
Phosphorus, not more than.....0.50%
Manganese, not more than 0.60%

Silicon, from 0.75% to 1.50%, as specified.

*Presented at the December ('07) meeting of the American Society of Mechanical Engineers.

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For malleable castings (white iron) the pig iron used should contain:

Sulphur, not more than.....0.04 %
Phosphorus, not more than.....0.225%
Manganese, not more than.....0.60%
Silicon, from 0.75% to 1.50%, as specified.

A variation of 10%, either way, from the above figures may be allowed.

Where light castings are desired, as for stoves and art work, the phosphorus is specified at 1.00% and over, and the silicon often as high as 3.25%. Similar specifications may be prepared to cover the rest of the 13 rather distinct grades of cast iron, with their more than 40 variations.

To enable foundrymen unacquainted with the metallurgy of cast iron to buy intelligently, the American Society for Testing Materials, through its committee on specifications for foundry iron, prepared schedules designating the composition of the very deceptive but well known, old grade numbers. Thus Nos. 1, 2, 3 and 4 are to contain 2.75, 2.25, 1.75 and 1.25% of silicon, respectively, fracture appearances being disregarded. Sulphur is specified at less than 0.035, 0.045, 0.055 and 0.065%, respectively, when estimated volumetrically, with an allowance of one hundredth more in case the gravimetric method is employed. A variation of 10% of silicon, either way, from the above figures is allowed; and the sulphur may vary 0.02%. A deficiency of over 10% and under 20% does not lead to rejection, but entails a penalty of 4% in price. This is eminently fair, and protects manufacturer and foundryman alike.

Ordinary foundry operations require as fuel anthracite, coke and soft coal, while producer gas, natural gas and oil are employed in the special brass furnaces and the open-hearth for steel and high grade iron. Necessity for specification is confined to bituminous coal and coke, and in the case of the former only the sulphur, and occasionally the ash, demands attention. It may be stated that no coal containing more than 2% of sulphur should be used in the foundry, and, preferably, the amount of this impurity should be limited to 1%. Similarly, the ash should be limited to 10%.

The employment of coke demands closer attention to moisture, to the remaining volatile matter, fixed carbon, sulphur, ash and sometimes phosphorus. Usually, however, the sulphur, ash and fixed carbon are sufficient to give a fair idea of the value of coke, apart from its physical structure, specific gravity, etc. The advent of by-product coke will necessitate closer attention to moisture. Bee-hive coke, when shipped in open cars where it absorbs much moisture, may, through inattention, cause the purchase of from 6 to 10 % of water at coke prices.

In good coke, the amount of sulphur should not exceed 1.2%, not over 11% of ash and over 86% of fixed carbon.

Limestone to be used for fluxing should be as rich as possible in carbonate of lime, for each unit of silica transformed into slag exacts its equivalent of lime and coke. Oyster shells form a most desirable flux, and fluorspar tends to thin the slag.

Use of the modern ferro-alloys will eventually be limited to the richer grades. It is wasteful to employ a rich alloy in the cupola; but in the ladle, removed from the further application of heat, the smaller bulk of the richer alloy causes a smaller reduction in the temperature of the molten iron. For the present, specifications are not required for these alloys, which are made from the best material, and should be low in the undesirable elements, sulphur and phosphorus.

In selecting scrap iron, each foundryman chooses wornout or broken castings similar in composition to the proposed product, so that the addition of this scrap to the pig iron mixture does not disturb the calculations.

Beyond the exclusion of burnt or very dirty metal, and of sizes so small as to cause waste in melting or too large to enter the charging door, specifications for scrap iron should be limited to a statement of the class of material wanted—machinery, malleable wheels, pipe, etc.

Weak castings and castings with pin holes or with pockets under the skin, are indicative of the use of burnt metal. Three hundredths of 1 per cent. of oxygen in solution in the iron as an oxide or combination of oxides is, in the case of white irons, sufficient to ruin them completely. The excessive "skulling" of ladles, and other troubles, can be traced to this cause. Thus oxygen in cast iron is far more powerful than even sulphur; yet the action of the former is little understood and does not lend itself readily to chemical investigation.

FERRO-CONCRETE: ITS APPLICATIONS TO ENGINEERING CONSTRUCTION*

A RÉSUMÉ OF BRITISH PRACTICE

By J. S. E. De VESIAN, M. Inst. C. E.

The object of the present paper is to present some notes upon the characteristics of ferro-concrete and its constituent parts, to describe briefly the principal systems employed in Great Britain, and to give particulars relative to applications of the material to various classes of engineering construction.

DEFINITION OF FERRO-CONCRETE.

Ferro-concrete, or reinforced concrete, is a combination of concrete and steel, in which the steel takes the tension stresses and the concrete the compression. It may rightly be termed a new material, conforming to laws of its own.

For instance, if a beam of concrete alone will extend under tension for, say, 1-10 in., a similar beam reinforced properly with steel will extend 1 in., or ten times as much, without showing signs of cracking or distress. The more the steel can be subdivided throughout the tension area of the concrete the better; or, in other words, small round bars are preferable to rolled sections of considerable area. By the suitable employment of such bars the designer is enabled to secure monolithic construction, in which all parts are connected absolutely without joints, and the reinforcement extends throughout the concrete, imparting the necessary resistance to tensile and other stresses to individual members, and by passing from one member to another the bars perform a most valuable duty by helping to distribute the forces over the different parts of the structure.

THE DURABILITY OF FERRO-CONCRETE.

The durability of concrete need hardly be entered upon after the experience we have had from olden times. Many old works give us instances of the preserving effects that good concrete has on iron.

Sewer pipes with steel reinforcements have been lately replaced on the Continent after 40 years' use, and the steel was found to be in good condition. As an instance, coming under the author's personal notice of the preservation of steel when imbedded in good concrete, the case of some piles at Southampton may usefully be mentioned. As these piles were originally made too long, the tops were cut off and thrown upon the foreshore, where they have remained for more than eight years, being covered and uncovered by the tides four times a day by the double tides prevailing in Southampton water. Some of these stumps have been examined by various eminent engineers, as well as by the author, and in every case the steel was found to be perfect ¼-in. only below the surface, while the bars which had been protruding where they were cut off were, of course, completely rotted away. Another very common example of the preservation of steel and iron by Portland cement is furnished by old ships, whose bottoms have been coated inside with cement when built. In such cases the plates have always been found in a state of perfect preservation under this coating when replaced in after years on account of corrosion from without.

THE SELECTION OF STEEL FOR REINFORCEMENT.

It is very important that the steel used in ferro-concrete should be of suitable quality for its intended purpose. Most experts in this class of work are now agreed that mild steel produced by the basic open-hearth process, with a tensile strength of from 28 tons per sq. in. to 32 tons per sq. in., and an elongation of 20% in a length of 8 ins., is the best for general employment. High-carbon steel is unsuitable, as is also any metal of variable quality, such as some kinds of Bessemer steel. Apart from the fact that high-carbon steel is apt to break unless bent with great care after suitable heat treatment, there is no economy in such metal because, as its coefficient of elasticity is not higher than the coefficient for mild steel, the higher elastic limit cannot be utilized fully without causing excessive stresses in the surrounding concrete, resulting in the cracking of the material and the conse-

*Slightly condensed from a paper read before the Civil and Mechanical Engineers' Society.

quent corrosion of the metal. It is immaterial what form of steel takes, but, of course, the most economical form, and the easiest to arrange, is the round bar. This section can be obtained from many different works of the requisite quality, and at competitive prices. Some patentees advocate special bars squeezed into various forms, or twisted, with the idea of giving a greater hold on the concrete. Corrugated bars of several different shapes are sometimes recommended by makers in this and other countries, on the ground that the steps or indentations so formed give an absolute mechanical bond, in addition to the natural adhesion between the concrete and the metal.

In the Hennebique system nothing but the round bar is used for tension members. Flat steel is used for the stirrups to resist the shearing forces. The adhesion of concrete to steel, which is an undoubted factor, is ignored. The bars are always flattened and opened at the ends to form a secure anchorage. The adhesion varies from 200 lbs. per sq. in. to 570 lbs. per sq. in. of surface in contact, so that as long lengths of steel are buried in the material there would be, as a rule, more than ample adhesion even if the bars were perfectly straight and not anchored into the concrete at all. Moreover, in the Hennebique stytem, even in the most straightforward beams and floor slabs, at least half the bars are bent upwards from the points of contraflexion and carried over the supports. The polygonal form so obtained insures the most secure anchorage possible.

PORTLAND CEMENT.

The quality of Portland cement used in ferro-concrete is of the greatest importance. The author prefers cement of the finest grinding, giving not more than a 20% residue on a 180 × 180-mesh sieve. The fineness of grinding after calcination is not a very conclusive test by itself. It would be better to have evidence of a very intimate mixing of the chalk and clay before calcination, but such a test would be very difficult to supervise, and in practice the best one can do is to see that the cement is delivered to the requisite fineness. The permissible expansion specified by the author under the Le Chatelier test is only half of that allowed by the British standard specification—viz., 6mm. and 3mm. fresh or seven days old. The time of setting should be from 50 to 90 minutes initial, and from 7 to 9 hours final.

Test blocks 4 ins. cube are required to stand the compressive stress of 600 lbs. per sq. in. at the age of 28 days.

SAND.

The sand to be used for cement mortar and concrete is specified by the author to be sharp and coarse, of all sizes from ⅛ in. downwards, and to be washed perfectly free from all traces of chalk, lime, clay or earthy matter. Sand of even size like "standard" sand is undesirable.

AGGREGATES.

The aggregate for the concrete should consist of the hardest local stone obtainable other than limestone, which is not admissible owing to its disintegrating under heat. Brick, cinder, coke breeze or slag concretes should be avoided for reinforced concrete work, as the concretes made with such materials are porous, or, as in the case of many slags, corrosive, owing to the sulphates and similar impurities in the material itself. Judging a slag from a chemically pure sample is not safe, for, as the nature of the charges in the furnaces vary, the slag from the same ironworks may not be of the same quality for many hours together.

In the choice of stone, a rounded shingle or gravel of hard stone is preferable to broken stones, as so many stones have a flaky cleavage, and the rounded pebbles make a more even and sounder concrete than these flaky pieces owing to the ease with which the sand and cement can fill the voids.

For ferro-concrete construction the author is in the habit of specifying that the aggregate shall be of all sizes from ¾ in. down to ⅛ in. As in the case of sand, it is highly important that the aggregate should be perfectly free from earthy matter of any kind.

PROPORTIONS OF CONCRETE.

The proportions of the materials for ferro-concrete necessarily vary with the character of the work to be executed.

In all engineering construction strength and durability are the most important considerations, but it is very often necessary, as in the case of pipes, reservoirs and marine constructions, to pay special attention to the question of impermeability. For resistance to fire it is well known that iron and steel are adequately protected when imbedded in good stone or gravel concrete.

The voids in the sand should be ascertained by filling a receptacle with perfectly dry sand, and measuring the amount of water it is possible to add without overflowing; then it is easy to calculate the voids as a percentage of

the sand. The percentage of voids in the aggregate can be determined in a similar manner. As the proportion of voids differs very much with the class of sand and stone, and the size and shape of the particles, it is desirable to test the percentage of the voids before arranging the exact mixture to be used in any work. The practice of using Thames ballast without separating the sand and pebbles may do for rough concrete work, but must never be followed in ferro-concrete construction, as it would lead to unsatisfactory results.

The average mixture adopted in ferro-concrete construction is as follows:

Portland cement, 672 lbs.

Sharp sand, 13½ cu. ft.

Washed gravel, 27 cu. ft.

These quantities when properly rammed yield about 31 cu. ft. of concrete.

CONCRETE MIXING.

The proper mixing of the concrete is of the greatest importance, and as good concrete may be improved 100% in strength by thorough mixing, it is preferable to employ a good machine mixer than to attempt to do this work by hand. The machine is certain to do it all alike, whereas no workman, however much he is looked after, can perform the operation so effectively. The concrete mixture should be just plastic, and must always be well rammed.

FIRE RESISTANCE.

Brick and coke concrete should not be used as aggregates in ferro-concrete. These materials make a concrete that is far too weak to withstand compressive and tensile stresses, and they make porous concrete, which exposes the metal to risk of corrosion.

Numerous experimental tests and actual conflagrations have demonstrated the security of ferro-concrete against the effects of fire.

A fire and water test was made on July 9, 1904, on a ferro-concrete chamber 5 ft. 8 ins. long by 6 ft. wide by 4 ft. 4 ins. high, two of the walls being 4 ins. thick, the other two 6 ins. thick, and covered by a flat roof 4 ins. thick. From the middle of the slab projected a ferro-concrete beam 4 ins. wide by 6 ins. deep, unsupported at either end. The top of the chamber was loaded with bricks and stones to 336 lbs. per sq. ft. over the whole area. Next to one of the 4-in. walls an enclosure with 4½-in. brick walls was built with a window and a doorway, and covered with a plain concrete roof. The object of this enclosure was to ascertain what increase of temperature would take place in a room divided by a thin ferro-concrete wall from another room in which a violent fire was raging.

At 11 a. m. on the day of the test a fire of wood and tar barrels was lighted under the chamber, and kept burning for two and a half hours, smoke and gases of combustion escaping through two square openings left near the roof. After this fire had been burning for some time the temperature reached 1,500° Fahr., but in the adjoining enclosure the temperature only rose 8° Fahr.

After two and a half hours jets of water were played on the outside and inside of the chamber. The concrete was then cut into with cold chisels and found to be as hard as it was before the test. The stability of the structure was not impaired in the least.

In the great Baltimore fire in America a ferro-concrete building with brick outer walls stood alone after the conflagration had ceased, and tests made on the floors gave even better results than when handed over originally to the client. The brick walls had fallen to a great extent, but the ferro-concrete was intact and uninjured.

Several similar instances giving equally good results have occurred on the Continent.

METHOD OF CALCULATION.

Up to a certain point the calculations necessary for the design of ferro-concrete are the same as those employed in the case of all other structural materials. When the forces have been determined for all the members of any particular structure, the cross-sectional area of the concrete may be made sufficient to resist the compression stresses with or without the help of steel as reinforcement, and a proper proportion added of steel in tension areas. The shearing forces are provided for by placing auxiliary reinforcement in such a manner as to relieve the concrete from forces tending to rupture it in vertical, horizontal, or diagonal directions, and to form a link between the compression and tension portions of the construction.

It is very easy to settle the cross-sectional area of concrete for resisting compression in any member, but when we come to add steel, whether for resisting compression or tension, difficulties and complications at once arise from the fact that the modulus of elasticity of concrete is variable. The modulus of elasticity is fairly constant for the type of steel used in reinforced concrete, but the modulus of elasticity of the concrete may vary from, say, 500,000 lbs. per sq. in. to 4,000,000 lbs. per sq. in., according to the quality of the cement,

sand and aggregate, the proportions of the mixture, the manner in which it is treated by workmen, the amount of water used, and the age of the material.

The trouble is further increased by the fact which has been proved by the tests of many experimenters such as Prof. Bach and M. Considere on the Continent, and Profs. Hatt and Talbot in America, that the modulus of elasticity of concrete varies with the stress to which it is subjected, so altogether we have no less than six different causes which may affect the modulus of elasticity of concrete. To use the words of an American author, Mr. A. W. Buel, concerning the numerous theories in existence, "while some of these theories are deduced from a few experiments, others are entirely theoretical, and none are fully demonstrated to be absolutely true."

The allowable stresses taken by the author and his colleagues are as follows:

Steel in compression, 14,000 lbs. per sq. in. 17,000 lbs. per sq. in.

Steel in compression, 14,000 lbs. per sqq. in. to 17,000 lbs. per sq. in.

Concrete in tension, nil.

Concrete in compression, 340 lbs. per sq. in. to 400 lbs. per sq. in.

Concrete in shear, nil.

Adhesion of concrete to steel, nil.

These stresses are far more conservative than those recommended by most authorities, but bearing in mind the various causes which may operate in actual construction to reduce the theoretical resistance of ferro-concrete, the author does not consider any increase would be desirable.

RELATIVE ECONOMY OF FERRO-CONCRETE.

A few figures will show that the combination of steel with concrete must be economical if properly done. The cost of a cubic foot of steel weighing, say, 490 lbs., at £8 10s. per ton, is approximately 37.2s., and the cost of a cubic foot of concrete at, say, £1 per cubic yard, is 0.74s. So volume for volume steel costs fifty times as much as concrete. The safe load on steel in compression may be, say, 15,000 lbs. per sq. in., and the safe load on concrete in compression, say, 500 lbs. per sq. in. This means that for equal areas steel will carry thirty times as much as concrete. The safe load on steel in tension being taken at 15,000 lbs. per sq. in., and the safe load on concrete in tension at, say, 50 lbs. per sq. in., the result is that for equal areas steel will carry 300 times as much as concrete.

Thus we find that concrete in compression costs only 30-50, or 3-5 as much as steel, while concrete in tension would cost 300-50, or six times as much as steel.

In ferro-concrete beams something must be put down for the concrete in tension whose resistance is not considered, but a great deal of expensive labor is required for preparing steelwork for use, and this costs more than the cheap labor which suffices for dealing with the concrete and plain steel bars of which ferro-concrete is composed.

It will be understood that the figures given are intended merely to illustrate in a rather rough-and-ready way the economic advantage of ferro-concrete over structural steel. The actual saving to be effected in any given case depends very much upon the market prices of materials and the locality where the work is to be executed. An example is the case of a highway erected last year over the river Suir, at Waterford, at a cost of £8,000, compared with over £20,000, the estimated cost of a steel structure, as stated by the engineer. This is perhaps an exceptionally favorable case, but it shows the possibilities of the new system of construction.

There is very little difference between the cost of timber and ferro-concrete structures such as wharves, quays and jetties, but the superior durability and strength of ferro-concrete, and the fact that it is immune from the attacks of destructive sea-worms, renders that material far cheaper in the long run, especially when used for marine work. In London and other cities, where the saving in annual unkeep, charges for painting, etc., are most important factors in favor of the use of ferro-concrete in such works as bridges, piers, etc., local regulations demand that walls made of it shall be as thick as ordinary brick walls; consequently there is no chance of effecting a saving by its use.

Fortunately, more reasonable counsels prevail in many parts of the country, and railway companies, who are exempt from ordinary building laws, have been able to employ ferro-concrete with much advantage and economy in the erection of goods stations, warehouses and other buildings. Government departments being also free from similar restrictions, have been able to make a considerable saving by the adoption of ferro-concrete, as testified by the answers to recent questions in Parliament, when it was stated that the cost of ferro-concrete structures recently erected was approximately 20% cheaper than brick construction.

SYSTEMS OF REINFORCED CONCRETE.

There are in Great Britain several systems of reinforced concrete, the best known being the Coignet armored concrete, the Considère spiralled and armored concrete, the expanded metal system of steel and concrete, the indented steel bar system of reinforced concrete, the trussed concrete steel and the Wells.

The expanded metal system imported some years ago from the United States has not been developed as a complete method of reinforced concrete construction, although the special form of metal network made by the company has been largely used for reinforcing concrete floors, partitions, walls, tanks, conduits and various structural details. The five systems in question and the Hennebique system all possess distinctive features, but are alike in the respect that steel bars of different forms are used with the object of reinforcing concrete against tensile, compressive and shearing forces.

BRIDGES.

Ferro-concrete girder bridges need not be discussed at length, because their essential parts are main and secondary beams, slabs, piers and walls designed on the principles already described. Still, although the design of the separate members may appear to be a very simple thing, it is not by any means an easy task to satisfactorily design a complete bridge.

Ferro-concrete arch bridges represent a special class of design, but when the lines of resultant pressures and the stresses in the arch ribs have been determined in the usual way, the bars and stirrups reinforcing the concrete against tension, compression and shear are arranged in the same general way that has already been described.

PILES.

One of the most interesting uses of reinforced concrete is for the construction of ferro-concrete piles. The fact that a baulk of concrete 60 ft. to 70 ft. long with some steel rods in it can be carried about like a piece of wood and driven through the hardest strata is wonderful.

A 14 × 14-in. ferro-concrete pile will in practice comfortably carry 65 tons to 75 tons with a large factor of safety. The use of these piles, therefore, becomes highly economical, as their number is necessarily far fewer than if timber were used, although foot for foot pitch pine may be the cheaper material, unless the length required is great. They are quite unaffected by sea water, are proof against the attack of sea worms, and can be driven through harder ground than any timber piles. That concrete is capable of standing great vibrations is proved by ferro-concrete piles, which have to stand about as severe a test in this direction as it is possible to conceive. The author has known of piles receiving upwards of 10,000 blows from a 2-ton monkey without damage. The weight of the monkey used with ferro-concrete piles should not be less than 2 tons, and should increase with the weight of the pile. As ferro-concrete piles are much heavier than timber, the blows of a light monkey would be ineffective for driving, and would tend to smash the head.

Piles of this kind have been extensively used in the foundations of bridges, wharves, quays, piers, jetties, reservoirs and buildings of all kinds.

PRACTICAL CONSTRUCTION.

Every ferro-concrete construction derives its value not only from the proper distribution and quality of its component parts, but also from the care which is exercised during its execution.

A good deal depends on the design, construction and erection of the molds, centering and shuttering. Contractors who take up ferro-concrete work for the first time must certainly be prepared to face a considerable outlay in timber for molds and accessories, but by careful attention to details they will be able to arrange matters so that the timber may be used over and over again.

All molds, centering and shuttering must be of well-seasoned timber, not liable to shrink or twist when exposed to the weather; they must have close joints so as to prevent leakage, and be of sufficient strength for supporting the weight of the materials and the impact of depositing and ramming the concrete without appreciable deflection.

Column molds should be made with one side open so that concrete can be deposited and rammed in layers of not more than 2 ins. thick, and the open side gradually closed up as the layers are finished by nailing boards across. In molding columns the vertical bars are first secured in position with the steel links threaded over them, tied up at a suitable height to leave a clear space for ramming. As the successive layers are deposited the links are lowered set by set, and so on until the column is finished. This insures all the concrete being of uniform consistency, whereas in columns with vertical or other lateral reinforcement which has to be fixed in place

before any concrete is deposited, the molds have to be formed with all sides fixed, and the concrete is poured in from the top and poked into place as well as possible by long rods. Besides the risk that pieces of wood, shavings, and other foreign materials may be accidentally dropped into the molds without being noticed, there is always the probability of voids, and the consistency of the concrete varies, the tendency being for stones to settle to the bottom and for the sand and cement to come to the top. The result may be that the actual strength of columns so molded is far less than the strength contemplated by the designer. When closed molds of this kind are used an inspection hole at the foot should be provided so that the foreman may see that no foreign material is present before concreting is started.

Beam models should be made so that the sides can be taken off before the bottoms are removed, so permitting air to get at the concrete and assist the hardening process.

Molds and centering of all kinds must be adequately supported and braced to guard against movement in any direction.

Extreme caution must be observed in removing the molds and centering. The supports must not be moved until it has been decided by some qualified and duly authorized person that the concrete has sufficiently set. Neglect of these precautions has been responsible for several serious mishaps on the Continent and in America, and the author fears that similar accidents will take place in this country if too much confidence is reposed in contractors lacking experience in reinforced concrete work, especially if not responsible to the designer.

Another important thing is that no load of any kind should be placed on green beams, deckings or floors, but in exceptional cases where it is imperative to do so the construction must be strongly propped up in order to throw the whole weight on the temporary supports, so that no fraction of it shall be borne by the ferro-concrete.

All bars used for reinforcement must be free from oil and paint, but if rusty the adhesion of the concrete will be better than if the bars were perfectly clean and bright. The reason is that the oxide of iron combines chemically with the cement, forming a protective covering of ferrite of calcium.

No welds must be made in any of the bars, and most bending should be done cold by the gradual application of force.

All the bars and stirrups must be laid and secured in the correct positions shown by the working drawings. Particular attention must be given to see that the stirrups are in actual contact with the main bars.

When the reinforcement has been laid out and fixed it should be carefully inspected by a responsible person to make sure that the intentions of the designer have been complied with in every respect. Too much care cannot be brought to bear on this point.

Concrete must be deposited as soon as possible after mixing. It is desirable that all concrete made shall be used up before suspending work, even for a short time. The balance of any batch not so used should be thrown away. After it has once commenced to set, the concrete must be protected from shocks and vibration, which interfere with proper setting. These are points to which very particular attention should be paid by some one in authority.

When the construction of beams, deckings or floors has to be interrupted before completion, the edges must be roughened with a cutting tool and thoroughly cleansed from all foreign matter before work is resumed on it. Cement grout must then be poured on the surface of the edge before the concreting operation is resumed, and special care should be taken to ram the fresh concrete as hard as possible on to the old work. The proper place for stopping concreting should always be decided by the resident engineer or some competent person.

Fresh concrete work should be freely watered for several days or if this cannot be done it should be kept in a moist state. This precaution is imperative when the work is exposed to heat.

The foregoing notes embody some of the chief points requiring careful and constant attention on the part of resident engineers, contractors and foremen, and they are sufficient to show that the rough-and-ready way in which mass concrete is treated for ordinary structural work cannot be followed with impunity in ferro-concrete construction.

THE DESIGN OF WATER RESISTANCES

FROM "THE ELECTRICAL ENGINEER," (LONDON)

In testing large generators, especially alternators, it is often necessary to employ water resistances, and Herr Carl Richter in a recent number of "Elektrotechnik und Maschinenbau" gives some useful notes on their correct design and dimensioning. The resistances often take the form of one or more casks filled with water and having metal electrodes dipping into them. Such resistances are cheaper than wire ones, and are especially suitable for alternating currents, as no reactive E.M.F.'s are set up in them. The specific resistance of pure water is extremely high (about 10^7 ohms per meter length and one square millimeter section), so that very high voltages can be dealt with in moderate-sized vessels. Except in cases where water is scarce, it is more convenient to arrange for a constant flow of water through the resistance, so as to keep below the boiling point, than to allow the energy to be dissipated in the form of steam. Experiment has shown that at ordinary temperatures and using wooden vessels the heat radiated is negligible compared with that generated, so that a fairly definite idea of the flow of water required to keep the temperature to any desired value can be obtained from theoretic considerations alone. The following table shows the supply of water necessary when 1,000 KW. is being dissipated if the temperature rise is limited so as to be below the boiling point to a greater or less extent:

WATER KEPT BELOW BOILING POINT.

Difference between temperature reached and temperature of supply water.	Necessary water supply in gallons per minute.
10° C.	318
20	159
30	106
40	79.5
50	63.5
60	53
70	45.2
80	39.7
90	35.2

If the water is allowed to boil, from 5 to 5¼ gals. per min. will be required.

In deciding the size of vessel and the distance apart of the electrodes for a given voltage and current, it is necessary to know the specific resistance of water at various temperatures and also the minimum area of electrode surface for each ampere passing. These values are approximately as follows:

Temp. in degs. C.....	30	50	70	85
Avg. Megohms resistance of water per sq. mm. section in 1 m. length.....	38	28.5	23	20
Area of electrode per ampere in sq. cms.....	2	3.7	6.3	10

In deciding the distance required between the electrodes for a given voltage—i. e., the effective resistance $r = \frac{\text{volts}}{\text{amperes}}$—both the specific resistance of the water and the method in which the current spreads out between the electrodes must be allowed for. In fact,

$$r = (l/f) \times \sigma \times K,$$

where l = distance between electrodes in centimenters; f = area of one face of an electrode in square centimeters; σ = specific resistance of the water in ohms per centimeter cube; K a variable depending on the shape of the vessel.

By making certain assumptions it can be shown that for rectangular vessels of width S and depth H, into which two electrodes each of width s dip to a depth h, the approximate value of K is $[s\,h \div (Hs - Sh)] \log (Hs/Sh)$, and for the special case of H = 1, S = 1, s = .5, the values of K for various depths h are as follows:

h =	1	.8	.6	.4	.2	.1	.05	.005
K =	.693	.629	.544	.446	.305	.201	.129	.023

Assuming a current density of .1 ampere per square centimeter and a specific resistance of 2,000 ohms per centimeter (20 megohms per meter and square millimeter), with K = .6 the distances required between the electrodes for various voltages are as follows:

Volts =	1,000	2,000	4,000	10,000	20,000	30,000
Distance between electrodes in cm. =	8.3	16.6	33.2	83	166	249

If the resistance is to be used for varying the load, it must be possible (1) to increase the distance between the electrodes, or (2) to vary

the depth immersed, or (3) to alter both distance apart and depth immersed simultaneously.

If the distance alone is varied, it must be done in proportion to the load—i. e., for one-quarter the load the distances must be four times as great as those given above. If the immersed depth is altered, care must be taken to avoid even increasing the current density above the allowable value, and for deciding this point the values given above for the variation of K with h will be found useful. In practice the minimum dimensions will be attained if distance and immersed depth are both varied simultaneously in such a way that the current density always has the maximum allowable value. Since

$$r = (1/f)\ \sigma\ K$$

and Current = volts/r = volts ÷ [(1/f) σ K],

∴ Current density = current ÷ f = volts ÷ lσ K.

∴ If, for given volts, the current density is to remain constant while the actual current varies, the product l × K must be made a constant. On this basis the distance required between the electrodes in order to reduce the load to one-quarter of its full value, instead of being four times the full-load distance, works out at only 2.1 times the full-load distance, making the same assumptions for specific resistance, current density and s/S as above.

DETINNING SCRAP

Apart from the prospecting of new ore deposits, other sources are being drawn on to their full extent for the production of tin. In this connection a most interesting field of investigation is the recovery of tin from tinplate scrap. Considerable scientific work has, therefore, been done to improve the methods of tin recovery. That this research has an important commercial aspect will be realized on a study of the figures relating to canning industries. The Swiss industries consume 70,000,000 tins annually, France uses 80,000,000 tins, the United States 700,000,000, besides large consumptions in other parts of the world. These figures indicate that there is a considerable product for the extraction of tin.

The scrap must be first cleaned by roasting or a caustic soda bath. It is also necessary to free it from solder. The industry must be one essentially in which large quantities of the raw material are assured. On the average, the tin in the scrap may be taken as 3% to 4% and if recovery is well managed the loss does not exceed 10% to 15%. Mr. G. Crudo, in a recent number of "Rasegna Hineraria," explains the methods used for extraction, which are based upon electrolysis. One method is based upon the property of hydrochloric acid to dissolve tin and transform it into stannous chloride, from which the tin can be extracted by electrolysis. The more commonly employed method is that based upon the use of a caustic soda solution, with or without oxidizing agents. The detinning tanks are generally made of iron plates communicating with the negative pole of a dynamo. The scrap, placed in suitable baskets, is immersed in the liquid and communicates with the positive pole. The requisite electric energy is not great, as with 10 KW. to 12 KW., working night and day, 10 to 12 tons of scrap can be treated and 200 kg. to 300 kg. of tin collected in 24 hours.

The strength of the caustic solution varies from 10% to 20% sodium hydroxide.

The product is not the purest tin, as the electrolytic production causes contamination by iron, as much as 3% of impurity sometimes being present, and it is only by special care that a purer product can be obtained. The spongy tin from the tanks is dessicated in hydro-extractors and the material compressed after mixing the metallic dust with molasses. The blocks are dried in the air and melted in a crucible in presence of tar. Thus the tin can be melted without appreciable loss, though the standard rarely exceeds 97% to 98%, and sometimes it is only 94% to 95%. The chief impurity is lead, which has not any noxious effect when the tin is intended for bronze or soldering alloys. To obtain purer metal the liquation process must be employed. The iron from the scrap is useful to the iron worker, owing to its malleability.—Australian "Mining Standard."

THE ELECTRO-THERMIC PRODUCTION OF IRON AND STEEL

By JOSEPH W. RICHARDS, Ph. D.

FROM "THE JOURNAL OF THE FRANKLIN INSTITUTE"

The electro-thermic metallurgy of iron has to do with two different problems.

1. The electro-thermic production of steel.
2. The electro-thermic reduction of iron ores.

Speaking chronologically, iron ores were reduced first to wrought-iron, and from wrought-iron steel was made by cementation in red-hot carbon. Afterwards iron ore was reduced in blast furnaces to pig iron, which was either used itself in the arts, or served as the basis of production of wrought iron by the puddling processes, or steel in the crucible.

FIG. 1. THE 1,000-HP. INDUCTION FURNACE AT VOELKLINGEN.

The development of the electro-thermic production of steel dates from the experiments of Siemens, in 1880, who attempted to use a combined arc-resistance furnace for melting down steel. In this case the material to be melted, held in a plumbago crucible, formed one pole and a water-cooled copper conductor the other pole. The arc between the two furnished the chief resistance and source of heat energy. The material to be melted, by its broken structure, poor contacts between the pieces and with the crucible, formed the smaller part of the resistance. With 1.6 HP., 500 grams of steel were melted in fifteen minutes; with 13 HP., 2,700 grams of wrought iron in twenty minutes. Since a kilogram of melted steel contains at least 300 calories, and one of melted wrought iron 350 calories, the heat imparted by the current was—

1.6 H P., 15 min. = 300 × 0.5 = 150 calories.
13 HP., 20 min. = 350 × 2.7 = 945 calories.

Since one HP.-hour = 642 calories, the full equivalent of the power used in the two cases was—

1.6 HP., 15 min. = 642 × 0.4 = 257 calories.
Thermal efficiency
= 150/257 = 0.584 = 58.4%.
13 HP., 20 min. = 642 × 4.3 = 2,761 calories.
Thermal efficiency
= 945/2,761 = 0.342 = 34.2%.

While these efficiencies do not appear at first sight high, yet when they are compared with the efficiences of 3 to 5% of the heating power of the fuel put into the steel while melting it by coke in a crucible set in a melting hole, the difference is striking.

The commercial question at once arises: Why was Siemen's method not profitable on a large scale? The answer is to be found in the imperfection of the furnace and not in its inefficiency. The water-cooled copper electrode was dangerous, for it quickly wore through.

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FIG. 3. BACK VIEW OF VOELKLINGEN FURNACE, SHOWING TILTING MECHANISM.

HP.). The latter furnace melts 80,000 lbs. of steel in twenty-four hours, with an expenditure of 600 kilowatt-hours per ton of steel if charges are put in cold, and 500 kilowatt-hours per ton with melted pig iron forming one-third of the charge. A furnace on the same principle to melt charges of 150 tons is now in course of construction at the Roechling Iron Works, Voelklingen, Germany.

Taking the above figures, it will be seen that the induction furnace is attaining a high degree of thermal and metallurgical efficiency. The waste during melting in the induction furnace is only 2.5%, whereas it is some 5% in open-hearth practice.

Taking the data given for the output of Kjellin furnaces of increasing sizes, the net thermal efficiencies are as follows:

One kilogram of melted steel, sufficiently over-heated to allow of casting, will contain at least 275 calories if high carbon steel and 325 calories if low carbon steel; say 300 calories for average steel. One kilowatt-hour furnishes 860 large calories, as its heat equivalent. We have then the following calculations for the furnaces in the order given:

700 kgs. melted in 24 hours by 58 KW.

$$\text{Efficiency} = \frac{700 \times 300}{58 \times 24 \times 860} = 0.18 = 18\%.$$

5,000 kgs. melted in 24 hours by 165 KW.

$$\text{Efficiency} = \frac{5{,}000 \times 300}{165 \times 24 \times 860} = 0.43 = 43\%.$$

80,000 lbs. (36,400 kgs.) melted per day by 736 KW.

$$\text{Efficiency} = \frac{36{,}400 \times 300}{736 \times 24 \times 860} = 0.72 = 72\%.$$

96,000 lbs. (43,600 kgs.) melted per day by 736 KW., if one-third is put in as melted pig-iron, carrying 250 cals. per kilogram.

$$\text{Efficiency} = \frac{(43{,}600 \times 300) - (14{,}500 \times 250)}{136 \times 24 \times 860} = 0.62 = 62\%.$$

Charging part of the charge melted is seen to lower the net thermal efficiency, but to increase the output of the furnace. With cheap power, the latter item is of the greatest importance.

The Héroult tilting electric furance resembles a tilting open-hearth furnace, with two large electrodes passing through the center of the roof. The electrodes are built up of carbon slabs, 170 cms. long and 36 cms. square, at a cost of about twenty cents per kilogram. The hearth is stamped in burnt dolomite, the roof silica brick; the electrodes are protected inside the furnace by water jackets, to prevent their combustion by the air. The furnace can hold 4,000 kgs. of steel, costs $10,000, and such a one has been in constant operation in La Praz, France, since 1903. The electrodes dip only into the slag, so as not to be dissolved by or carbonize the bath. The current used is 110 volts by 4,000 amperes, alternating, and the principal resistance and seat of generation of heat is in the slag between the ends of the carbons and the metal. A disadvantage of this furnace is that it cannot operate without a considerable layer of slag being present.

In such a furnace steel can be made in a variety of ways. Mr. Héroult has preferred to

make it from the cheapest raw materials, by processes similar to ordinary open-hearth practice. As is well known, this involves the use of pig-iron, scrap iron or steel and iron ore. The only difference between the two processes is that in the open-hearth furnace there may be considerable oxidation by the gases in the furnace, but in the electric furnace iron ore must be relied on as the oxidizing agent; it is therefore used to a larger extent than can be used in the open-hearth practice. Considerable lime is added to help form a fusible and basic slag. The oxidation of the impurities consumes time, and therefore the amount of electrical energy required per ton of steel is greater than in the cases cited in the Kjellin induction furnace, where high-grade pig iron and clean scrap were simply melted together in proper proportions.

A charge composed of 5,733 lbs. miscellaneous steel scrap, 430 lbs. iron ore and 346 lbs. lime was placed in a Héroult furnace, and in five hours and twenty minutes was completely melted to soft steel, yielding 5,161 lbs. During the melting 1,680 kilowatt-hours of electric energy were used.

The thermal efficiency of the furnace figures out as follows:

The steel scrap is 572 lbs. heavier than the soft steel produced, or 10%. It is very evident that the iron ore used (probably 90% Fe_2O_3) oxidized some of the carbon, manganese, etc., of the scrap, and that the scrap itself was probably oxidized. Miscellaneous scrap may easily be rusted so far as to lose 5% of its weight while melting down. Calling the soft steel practically pure iron, and the loss of the scrap to represent iron oxide going into the slag, we have as the net result of the melting 5,161 lbs. of pure iron and a slag containing silica, iron oxide and lime, weighing approximately 1,249 lbs. (Ferrous oxide, 860 lbs.; silica, 43 lbs.; lime, 346 lbs.).

Heat in melted soft steel = 5,161 × 340 = 1,754,740 lb.-cal.
Heat in slag = 1,249 × 550 = 686,950 lb.-cal.

2,441,690 lb.-cal.
= 1,109,850 kg.-cal.

Heat value of current used = 1,680 × 860 = 1,444,800 kg.-cal.
Efficiency = 1,109,850 ÷ 1,444,800 = 77%.

In working this furnace, with these materials, the slag produced is a necessary part of the operation, and the heat it contains may be taken as usefully applied heat.

These furnaces lend themselves very well to use in connection with melting pig iron from cupolas or blast furnaces, or melted steel from the Bessemer converter or open-hearth furnace. The electric furnace is fitted to take hot metal, the product of the ordinary steel furnace, and by reason of the higher temperature available to make a slag which will entirely dephosphorize the metal. Such working leaves on the other furnaces the calorific burden of melting the charges and giving them to the electric furnace fully liquid, leaving to the latter merely the task of raising the temperature a little higher and smelting upon them a very basic slag. In such cases, steel corresponding in quality to crucible steel is obtained at but a small cost per ton advance upon that of the Siemens or Bessemer steel from which it is made. The electrically imparted heat is here mostly used to supply radiation losses, and only a minor fraction to increase the temperature of the steel. We cannot, therefore, in justice to the furnace, calculate its thermal efficiency in the manner applied to the case of melting a charge down. In fact, in such cases we can only compare different furnaces on the basis of weight of metal kept melted per given time, e. g., per ton of metal kept melted one hour.

Electro-Thermal Reduction.—The most interesting application of electric furnace methods to the metallurgy of iron is in the line of producing cast iron, pure iron or steel direct from iron ore. To this may be added the production of ferro-alloys, either by the reduction of other metallic oxides in the presence of iron or mixed with iron ore.

The raison d'etre of the ferro-alloy industry is as follows: In the blast furnace, metallic oxides more difficult to reduce than iron oxide are decomposed to varying and often to only trifling degrees. The blast furnace will easily reduce 99% of all the iron oxide put into it, losing only 1% of it in the slag, unreduced. Manganese oxide is not so completely reduced; perhaps 50 to 75% of it is reduced to manganese and alloys with the iron, forming a product as high as 85% manganese, while the slag contains the rest, as unreduced MnO. Since good manganese ores are scarce and expensive, this loss is annoying and costly. Silica is always present in the blast furnace, and up to 25% of it may be reduced to silicon, forming a 10 or even 15% silicon pig, but there the blast furnace reaches its limit; the temperature is not high enough to produce a richer silicon alloy. A low per cent. chromium alloy may

FIG. 4. THE DISSTON FURNACE.

be made in a blast furnace, but a great waste of chromium in the slag; a high per cent. chromium alloy cannot thus be made. Tungsten oxides can be reduced to ferro-tungsten in crucibles, but only to a low per cent. tungsten alloy and with much unreduced tungsten in the slag. Titanium, vanadium, boron, cannot be reduced to any appreciable extent by carbon and non-electric heating. In all these cases cited, alloys much richer in the non-ferrous metal, and much more complete reduction of the material used, can be obtained in the electric furnace.

Just as electrically-made steel has first found a footing as a competitor of the most expensive kind of steel—crucible steel—so electrical reduction has first found footing in the metallurgy of iron in the production of the most expensive and difficult ferro-alloys.

Reduction of Iron Ores.—The Canadian Government appointed a commission in 1905 to report on the possibilities of the electrical production of pig iron, and in 1906 gave it authority to supervise experiments to determine the feasibility of this matter as applied to Canadian ores. The experiments were carried out under the supervision of Drs. Haanel and Héroult, and were the subject of an elaborate report. Several hundred tons of pig iron were made from hematite and magnetite ores, in an electrical furnace of the type shown in elevation and plan in Fig. 7, showing the possibility of producing a ton of pig iron by about 0.25 HP.-years of electrical energy, and demonstrating the commercial practicability of the operation in favorable localities. Later, Dr. Héroult has erected for Mr. Nobel, in Shasta County, California, a 2,000-HP. tri-phase furnace, shown diagrammatically in Fig. 8, which started in operation July 4, 1907, and is in reality the pioneer electric pig-iron furnace of the commercial world. The whole subject is in an elementary, but nevertheless a very rapidly developing stage.

Problem.—Assuming 100 kgs. of an ore containing 9% Fe O and 10 SiO_2, fluxed by ad-

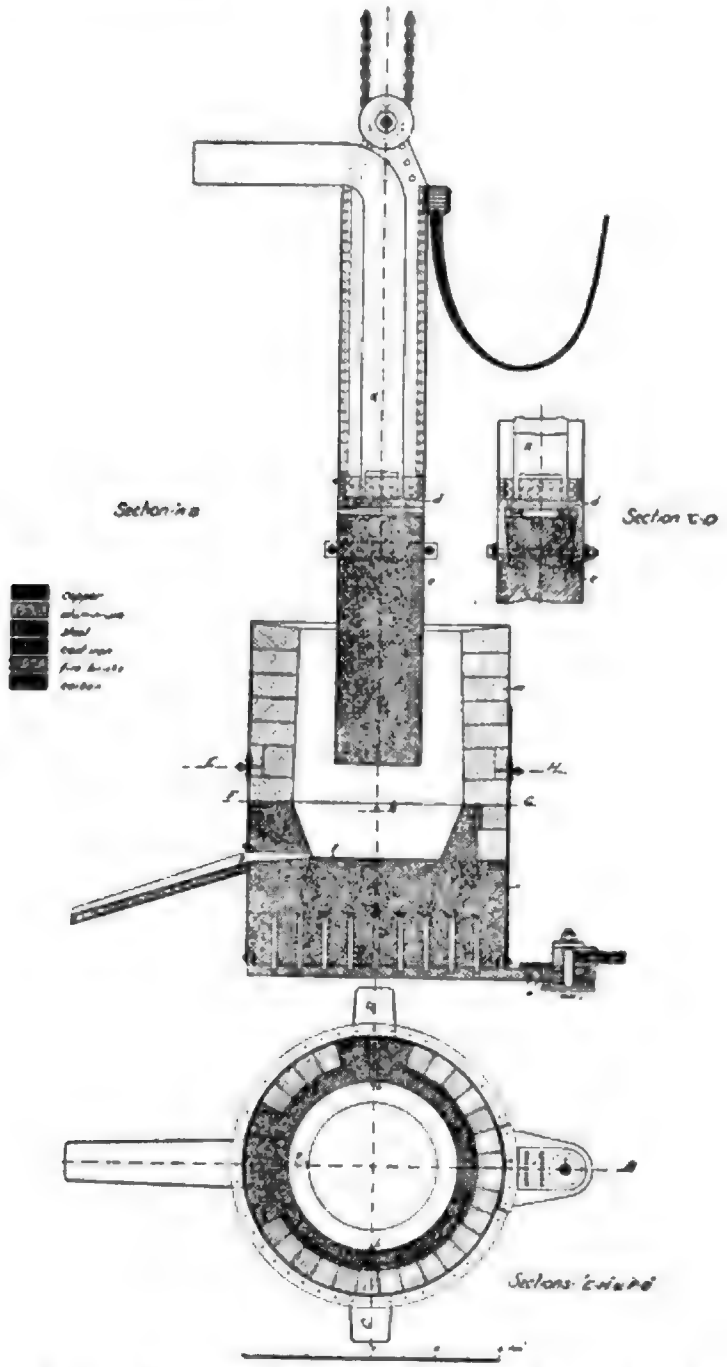

FIG. 7. ELECTRICAL FURNACE USED AT SAULT STE. MINE FOR REDUCING IRON ORE TO PIG IRON.

Reduction of Iron Ore.—This is really only a special case of the ferro-alloy practice, since if the other metallic oxides are left out we can get cast iron, steel or pure iron, according to the excess of carbon used. Iron oxides are reduced in the blast furnace principally by CO gas formed by combustion before the tuyeres. The reaction usually lies between these two equations:

$$Fe_2O_3 + 9\ CO = 2\ Fe + 3\ CO_2 + 6\ CO.$$
$$Fe_2O_3 + 6\ CO = 2\ Fe + 3\ CO_2 + 3\ CO.$$

These reactions require either 9 C (108 parts) or 6 C (72 parts) to be burned at the tuyeres for every 2 Fe (112 parts) of iron produced. This means that the fuel used must be some 75 to 100% of the weight of the iron produced. Modern practice averages 100%, more is commonly used in producing high silicon iron, and less is attained usually only with pure fuel and purer ores than the average.

In the electric furnace there is no blast, and the 6 CO or 9 CO noted above as formed by combustion at the tuyeres can be assumed as formed by reduction of iron oxide at the hot-

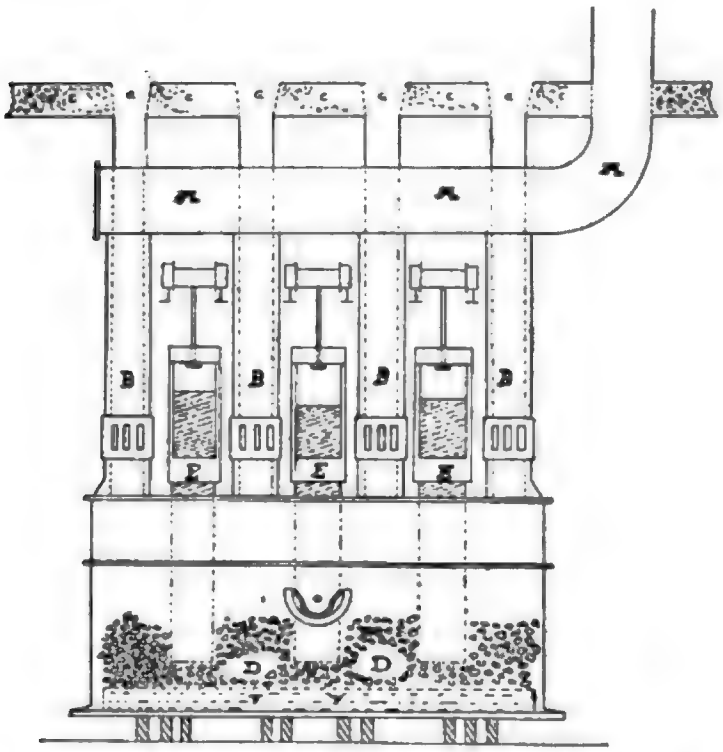

FIG. 8. A TRI-PHASE ELECTRIC FURNACE OF 2,000 HP. USED IN SHASTA, CALIFORNIA, FOR THE PRODUCTION OF PIG IRON

test part of the furnace. The reaction would be:

$$3\ Fe_2O_3 + 9\ C = 6\ Fe + 9\ CO.$$
$$2\ Fe_2O_3 + 6\ C = 4\ Fe + 6\ CO.$$

This means that for a given weight of carbon used in the two furnaces, the electric furnace ought to turn out three or four times the weight of iron (8 Fe or 6 Fe instead of 2 Fe), or for a given weight of iron produced that only 1/3 to 1/4 as much carbon need be used, or say 25 to 35% of the weight of iron made, 1/3 to 1/4 of 75 to 100%.

These figures are fully borne out in practice, in that experiments have approximated these requirements. For instance, at Livet 0.34 ton of coke was used per ton of pig iron produced, but considerable iron and manganese remained in the slag. In another experiment 0.41 ton was used, with still iron and manganese left in the slag. In the first case 0.226 E.HP.-year was used per ton of iron produced, in the second, 0.475. If we plot these figures we find that 0.28 carbon per ton of pig iron is the quantity which is to be approached as the efficiency of the furnace is increased. For instance, if the furnace could be run on 0.1 HP.-year, the carbon required would probably be simultaneously reduced to 0.30 ton per ton of pig iron. This statement really puts the cart before the horse; it should properly read: If the furnace by proper design and running, was run with 0.30 ton of fuel for reduction per ton of pig iron, the power consumption would probably be reduced to 0.10 HP.-year per ton of product.

These figures appear anomalous. It seems like saying—leave more for the electric current to do, and it takes less current to do it. The explanation of the paradox is that in the first place, the electric current does not perform any reduction in either case or in any case. So that decreasing the carbon used does not put any more work of reduction on the current; and in the second case the carbon is burned in larger proportion to CO, thus giving not only more heat per unit of carbon but actually giving more heat from the smaller weight of carbon than was produced in the first case from the larger weight. By using less carbon (within limits, of course,) we actually get more heat generated by its oxidation, and therefore can get along with less electrical energy.

The point to be recognized and kept clearly in mind is that a given weight of iron reduced liberates a given weight of oxygen. We have approximately 0.4 ton of oxygen set free for a ton of pig iron produced. If this burns carbon only to CO, it can burn 0.3 ton of carbon, and give off in doing it 729,000 calories. If it burns carbon half to CO and half to CO_2, it can burn only 0.225 ton of carbon, but it will

generate in doing it 972,000 calories. If it could possibly burn carbon all to CO_2 (it cannot, as far as we know, under these circumstances) it could burn only 0.15 ton of carbon, but would generate thereby 1,215,000 calories. We therefore reach the important conclusion, that the less carbon is used in the electric furnace reduction of iron ore the more heat will be generated by its combustion, and the less electric energy will be required; within the limits, of course, of using enough carbon to perform reduction.

The key-note to economy in electric furnace reduction of iron ore is the reduction of the carbon in the charge to the lowest possible minimum. This will coincide with the largest possible production of CO_2 in the furnace gases, and the analysis of the escaping gases will give an exact criterion of the running of the furnace. It will also coincide with the minimum of electrical energy needed to run the furnace.

How can these conditions be attained? By studying the design of the furnace, and particularly the conditions favoring the reduction of iron oxide by CO gas, and formation of CO_2. These are: slow passage of gases through the charge; high column of charge; uniform but small size of the pieces of charge material; absence of dust or fines in the charge. Electro-metallurgical engineers should give their best attention to the study of these conditions and their accomplishment. If this is coupled with a study of the best shape of the furnace, and the best means of reducing radiation and conduction losses, the minimum of carbon required, and of electrical energy necessary will be attained.

Heat to Decompose Carbonates.—This is 1,026 calories per unit of CO_2 driven off limestone; 846 from dolomite. It may amount to a large item if much raw flux is used.

Heat Conducted to the Ground.—This will be very variable, according to the size of the furance, and it may be 10,000 calories per 100 kgs. of iron produced, and in other cases two or three times that much.

Heat Conducted to the Air and Radiated.—This may be as low as 10,000 calories per 100 kgs. of pig iron, and again may be 50,000, in a small furnace poorly designed.

Reduction of Other Metallic Oxides.—These may form an important part of the charge, and the heat required to reduce silicon, manganese, and phosphorous may be quite large; also the reduction of lime to form calcium sulphide is not to be neglected on a high sulphur charge.

A STUDY OF ROOF TRUSSES*

By N. CLIFFORD RICKER, D. Arch.

The investigation described in this bulletin had for its original object the determination of a formula for the weight of roof trusses more accurate than those now in existence. As the investigation progressed, however, other topics arose and some interesting results were secured, which it is believed will be of value to architects and engineers. Very little study has been devoted to roof trusses in comparison with the thorough treatment of bridge trusses by eminent writers. The chief result of the work has been the devising of a method to save time and labor by presenting data in a form most convenient for comparison. This system will be found convenient in calculating and designing roof trusses to satisfy given conditions, whether constructed of wood and steel, or entirely of steel.

In the determination of weights, general mathematical methods may be readily applied to most forms of bridge trusses, especially those with parallel chords; these are, however, less valuable for roof trusses where far more varied conditions must be arbitrarily limited in order to make such methods applicable. The results are then of doubtful worth. A more practical method of investigation was therefore chosen. For a single common type of truss (with horizontal tie beam, vertical tension members and inclined struts), nearly fifty trusses of varied span (20 to 200 ft.), rise, and distance apart were calculated and designed in the same general way. Next the weight of each truss was carefully computed; and if this materially differed from the assumed weight of the truss, the necessary corrections were made in the sectional dimensions and weight of members.

The verticals were steel rods with upset

*Condensed from Bulletin No. 16, University of Illinois Experiment Station, Urbana, Ill.

ends; all other members were long leaf pine timbers. Splices in the tie-beam and its connection with the principal were made with vertical steel fish plates and through bolts. A purlin rested on each apex of the principal and supported the rafters on which was laid ⅞-in. matched sheathing covered by a painted tin roof.

Several steel trusses of different spans were also designed and computed. Their weights for spans of 100 and 200 feet were found to be about the same as those of long leaf pine and steel trusses. It is very probable, however, that for short spans, steel trusses are somewhat heavier than those of wood and steel given by the formula; their connections are far more complex and certainly require the addition of a larger per cent. to the center length weights of truss.

In accordance with the usual custom of engineers the roof was assumed to support a snow load and wind pressure at the same time, although the writer believes that this extreme condition rarely occurs. The assumption, however, provides some surplus strength for contingencies, such as unusual snow fall, very violent winds, etc.

The snow load varies with latitude, but was here assumed at 20 lbs. per sq. ft. of horizontal projection of roof for location of Chicago. Denoting by i the angle of inclination of roof surface with the horizontal, we have 20 cos i = snow load in lbs. per sq. ft. of inclined roof surface.

Wind Pressure Normal to Roof.—After a critical examination of a number of formulas, the following empirical expressions were adopted as being sufficient and convenient in use:

Taking the angle i in degrees,

$P_n = 2/3\ i$, for P = 30 lbs. per sq. ft. horizontal pressure.

$P_n = 8/9\ i$, for P = 40 lbs. per sq. ft. horizontal pressure.

$P_n = 10/9\ i$, for P = 50 lbs. per sq. ft. horizontal pressure.

These formulas are applicable for values of i less than 45°; for higher inclinations, the normal and horizontal pressures are equal.

The empirical formula derived for the weight of the truss is

$$W = \frac{S}{25} + \frac{S^2}{6{,}000},$$

in which S = span in feet, and W = weight of truss in lbs. per sq. ft. of horizontal projection of the roof. For white pine and steel trusses, take 0.9 of formula value.

Other important deductions from the series of experiments are as follows:

The most economical distance between trusses is 25 ft.; the total weight of the roof, however, is a minimum when the trusses are spaced 15 ft. apart.

The weight of the truss, and very nearly that of the entire roof, is a minimum for a panel length of 20 ft.

No advantage results from the use of more than 2 purlins per panel of 25 ft. or of more than one for panels of ordinary size.

Raising or cambering of the lower chord is not economical, and is done only for effect.

The weight of trusses and that of the roof are each a minimum for a rise of 35 ft. which is practically 1/6 the span, identical with the ratio for ordinary bridge trusses.

RECENT GAS ENGINE EFFICIENCY TESTS

In the Third Report to the Gas Engine Research Committee, read before the Institution of Mechanical Engineers on Jan. 17, Professor Frederic W. Burstall summarized the results of experiments made with a 150-HP. gas engine of special design. The internal diameter of the engine cylinder was 16 ins., and the stroke 24 ins. In place of using the standard type of admission valve on the top and exhaust on the bottom, an entirely new breech end was constructed, with the admission and exhaust valves horizontal, care being taken that the interior of the cylinder should have a perfectly flat end, like the cylinder of a steam engine. The engine was of the positive scavenging type and, in order to prevent, as far as possible, any preignitions occurring through hot surfaces, every part of the engine exposed to the flame was water-jacketed. The tests were undertaken to determine in the first place the thermal efficiencies based on the indicated horse power, at various compressions, having regard to the richness of the mixture; and, in the second place, to formulate, if

possible, the law connecting efficiency and compression. The tests were made at full power of the engine, running on a producer gas having a calorific value (lower) of 160 B. T. U. per cubic foot. It was found that in all the tests the mean pressure which gave the highest economy ranged between 85 and 95 lbs. For this particular engine the most economical compression pressure is about 175 lbs. per sq. in. The particular compression that will give the maximum economy, of course, varies according to the design of the clearance spaces, but it does not seem to be probable, according to Professor Burstall, that a better design than that found in the experimental engine can be obtained. The tests showing the highest thermal efficiency (41.5%) were made under the following average conditions: Compression pressure, 172.5 lbs.; mean explosion pressure, 329 lbs.; mean effective pressure, 92 lbs.; I. HP., 95.1; compression ratio, 7.22; cu. ft. of gas per hour, 3,632; cu. ft. of gas per I. HP.-hr., 38.23; B. T. U. per cu. ft. of gas (lower value), 161. The power required to drive the engine was 22 HP., which, applied to the tests giving the highest thermal efficiencies, yields a thermal efficiency of 32%, reckoned on the brake horse-power.

GEAR ARRANGEMENTS AND RATIOS IN MOTOR-CARS

CONDENSED FROM "ENGINEERING."

The fact that in the recent Scottish trials of motor cars no less than 27%, or 22 out of the 81 cars which completed the trials, failed to take their load up all the hills, shows that the calculation of the gears for a car is not yet always understood. The fact that in the three and four-speed cars the ratio between the top and bottom speeds varied from 2 to 1 to 10 to 1 confirms this view. There were cases, no doubt, in which the failure in hill-climbing was due to defects in the engine, but in the majority of cases it was simply due to the bottom gear not being low enough, and the result could perfectly well have been foretold.

In the present state of knowledge as to motor cars there are ample data to calculate the performance of a car beforehand with as great accuracy as that of most other kinds of machinery, and therefore the whole subject of gears should be treated in a scientific manner. In order to calculate the performance of a car under certain specified conditions, we want to know the resistance and the tractive effort.

The resistance depends on—

1. That due to rolling resistance on the road.
2. That due to the gradient.
3. That due to wind.

At the speeds at which reasonable motorists go, the latter is comparatively small, and for hill-climbing purposes negligible.

The tractive effort depends on—

1. The torque the engine will give.
2. The friction of transmission.
3. The ratio of gear between the engine and back wheels.
4. The diameter of the back wheels.

Although we seldom know all these factors with absolute accuracy, we know them near enough for practical calculations.

Taking the question of the greatest resistance to be overcome first, we may take it for granted that a modern motor ought to be able to take its full load up any hill on a road habitually used for horse traffic. This means that it must take it up short stretches of 1 in 4. The resistance expressed in pounds per ton (2,240 lbs.) due to this gradient is 560 lbs. Rolling resistance will vary a good deal with the surface of the road; but as the surface on steep hills is generally bad, it may reach 100 lbs. per ton, making a total tractive force required of 660 lbs. per ton.

Assuming that we know the brake horse-power of the engine at the revolutions at which it gives its greatest torque, we can calculate the tractive effort as follows:—

$$\text{The torque in inch-pounds} = \frac{\text{Brake horse-power} \times 63{,}024}{\text{Revolutions per minute}}$$

$$\text{The tractive force in pounds per ton is then} = \frac{\text{Torque} \times \text{ratio of gear} \times \text{efficiency of transmission}}{\text{Weight in tons} \times \text{radius of driving wheels in inches}}$$

If there should not be an actual brake test of the engine available, as in the case of a design which has not yet been built, it is usual to estimate the power the engine will give by assuming a torque equivalent to a mean pressure in the cylinder which is estimated by experience. In this case it is simpler to use the assumed mean pressure directly to calculate the tractive force, as follows:—

$$\frac{\text{Tractive force per ton} = \text{Cylinder area} \times \text{stroke} \times \text{mean pressure} \times \text{ratio of gear} \times \text{efficiency}}{\text{Circumference of driving wheel} \times 2 \times \text{weight in tons}}$$

all dimensions being in inches. If more than one cylinder, the total area to be taken.

In these formulas the only uncertain factor, if we have a brake test of the engine, is the coefficient of friction of the transmission gear. Absolutely definite experiments on hardened-steel gear wheels running under the varying conditions of motor work are wanting; but an assumption of a loss of 8% for each pair of gear wheels through which the power passes corresponds very closely with the actual performance of cars on the road.

If we assume that there is a loss of 8% of the power transmitted for each pair of gear wheels it goes through, the following will be the efficiencies of the various arrangements. In these some small losses, such as that of the back shaft, when running idle, and that of the universal joint, are omitted. These may vary slightly in different cars, especially that of the universal joint. In a well-designed car, however, this should run practically straight, and all the small losses together should be a negligible amount. The shaft-to-shaft gear box will have an efficiency of 92% on all the speeds, and as the efficiency of the bevel drive is 92%, the efficiency of the whole transmission from the engine to back axle will be 92% of 92%, = 85%.

The direct-drive gear box, when the direct speed is in use will have an efficiency of 100%, and therefore the efficiency of the whole transmission will be 92% of 100%, = 92%.

The direct-drive gear box, with any of the indirect speeds in use will have an efficiency of 92% of 92%, = 85%, and the efficiency of the whole transmission will be 92% of 85%, = 78%. In the case of a car with side chains there will be the friction of these in addition, which will lower the above efficiencies about 5% all round.

In estimating the torque we are likely to get from an engine, we should assume that it is not likely to materially exceed that corresponding to 95 lbs. mean pressure, even if the compression, etc., are arranged for getting the greatest possible power; though a few engines, when carefully tuned up, may reach 100 lbs. If, on the other hand, power is sacrificed to other considerations, such as extreme silence, it may be a good deal less.

It is, perhaps, easiest to show the working of a formula by taking a definite instance. Let us assume a car with four cylinders, 3½ × 5 ins., weighing, with passengers, 3,360 lbs., having 32-in. driving wheels, a live axle, and a direct drive on the top speed. Assuming a torque equivalent to 95 lbs. mean pressure and 78% efficiency on the low speed, we get a tractive force for gear ratio 1 to 1 of

$$\frac{38.48 \times 5 \times 95 \times 0.78}{100.5 \times 2 \times 1.5} = 47.3 \text{ lbs. per ton.}$$

Consequently for a tractive force of 660 we must have gear ratio of

$$\frac{660}{47.3} = 14.0 \text{ to } 1,$$

equivalent to a speed of 8.2 miles an hour at 1,200 revolutions per minute of the engine.

A moderate-powered car should probably be able to take its full load up about 1 in 16 on a road with a pretty good surface, which means a tractive force of about 200 lbs. per ton, i. e., a ratio of 3.3 between the tractive force on the top and bottom speed. The ratio of gear between the top and bottom speeds will have to be greater than this, owing to the lower efficiency of the low speeds, which is only about 85% of the top. It will therefore be about 3.9 to 1. In a low-powered car the ratio should be greater than this, as we shall not be so ambitious as to go up hills at our top speed. In a very high-powered car, however, it can be a good deal less. Probably while the low and moderate-powered car wants a ratio of about 4 to 1, the high-powered car should be about 3.5.

HEAT-INSULATING MATERIALS

In a recent issue of "Stahl und Eisen," Dr. Steger discusses the problem of providing a good heat insulation for metallurgical furnaces and apparatus.

The simplest heat insulator is non-circulating atmospheric air. But the method of enclosing an apparatus within a double jacket, with a sufficient space of air between the walls, is not always applicable. As a substitute it is possible to use brick containing numerous holes and pores filled with air.

The manufacture of porous brick from kieselguhr (infusorial earth) has long been known. The kieselguhr, mixed with a binding material like clay or water glass, is formed into brick and burnt. Care must be taken in burning, since too much heat causes sintering and the heat-insulating property is lost. A properly treated brick of 9⅞ ins. length may be heated to red heat at one end, while the other end is heated so moderately that one can touch it with the hand.

As kieselguhr is not always available, heat-insulating brick has been made from other materials which are better conductors of heat, but which are provided artificially with numerous pores. For this purpose a mixture of clay and finely divided organic substances is used. The latter burn, when the brick is heated, under the action of air which enters into the mass through the many cracks which form. There are thus produced innumerable pores. Suitable materials to be added to the clay are finely divided peat, bituminous coal, sawdust, straw, wool waste, tar, etc. They are added to the clay mud as a fine powder, and the mass is thoroughly stirred and mixed to make sure that the pores are uniformly distributed throughout the mass. The clay must be "fat," so as to be able to absorb a large quantity (up to 75%) of organic additions. These additions contribute to the thorough burning of the clay and reduce the amount of fuel required.

Under certain conditions it may be advantageous to burn out the added organic substance not entirely, but only partly, so as to gain not only porosity, but also strength.

Brick dense on one surface, but otherwise porous, is made by pressing a thin layer of clay and chamotte, putting on it clay of the same quality and the same content of water, but mixed with an oxidizable material, for instance, sawdust, pressing again, drying and burning. The sawdust burns out. Such brick is an excellent insulator for metallurgical furnaces.

The highest degree of porosity in brick can be obtained by mixing kieselguhr and organic substances with very small quantities of binding materials like clay or water glass. During the burning the organic substance prevents the mass from sintering together and becoming dense and compact. After the organic substances are burned out care must be taken to maintain the proper temperature. The finished brick has the pores due to the burned-out organic substances and the natural pores of the kieselguhr. Of special advantage is the addition of very finely powdered cork with kieselguhr. Cork contains innumerable pores, even in the smallest particles. If it is desired to have in the product regular channels running in certain directions, then thin wooden rods or threads are placed in proper distances from each other, which later burn out.

Very suitable as a heat-insulating brick for roof construction, are hollow blocks. Thus Hourdis brick, which is much used in Southern Europe as an insulating brick, is 9⅞ ins. broad, 2⅜ to 4 ins. high, and 1 ft. 8 ins. to 3 ft. 3 ins. long, but the thickness of the walls is only a little more than ¼ in. Thin partitions pass through the hollow spaces so that a number of channels of square cross-section are formed. This brick is made from clay which contains a certain amount of magnesia, about 5%, and 7 to 8% of iron oxide and 12% lime. Although this brick is made from a clay, which is not really refractory, it stands temperatures up to 1,000° C.

For higher temperatures it is necessary to use good special clay for making the brick, and it is advisable to make the thin walls of these hollow blocks porous in the manner described before. To increase the strength of the blocks they may be made dense and non-porous on the outside.

The use of hollow and porous brick of light weight reduces the cost of erecting light structures. This brick is also useful for damping sound.—"Electrochemical and Metallurgical Industry."

NOTES ON ENGINEERING AND APPLIED SCIENCE FROM ALL SOURCES

The Cutting Speeds of High-Speed Tools.—In a communication in a recent issue of the "American Machinist," Robert Grimshaw gives the speeds of the new rapid-cutting steels, as stated in a report made to the German Society of Engineers by Prof. Hermann Fischer. The average speeds given for roughing cuts in lathes in feet per minute are 50-65 for soft cast iron and steel of 85,000 to 100,000 lbs. T. S. per sq. in.; 40-50 for hard cast-iron and steel castings, and 65-100 for wrought-iron and steel of 57,000-64,000 lbs. T. S. per sq. in.

The Use of Peat as an Economical Fuel.—In an address before the Institution of Electrical Engineers, at Dublin, T. Tomlinson, M. I. E. E., recently made some interesting statements regarding the value and cheapness of the use of peat as a fuel. He first showed that sufficient sulphate of ammonia could be recovered per ton of peat to make the fuel cost nothing. He then showed that there is obtainable from one ton of dried peat or ten tons of peat in the bog about 1,000 B. HP.-hours as power, when the peat is used in connection with a gas-engine and producer plant.

Pumps for Liquids should be constructed from materials which are not attacked by the liquids elevated. The following, according to "Die Fördertechnik," are the best materials for the liquids mentioned:

Cast Iron: Ammonia; tar; mineral oils.

Gun Metal: Vegetable oils; salt water; molasses; beer; lime water; weak acetic acid.

Lead: Strong acetic acid.

Lead (with a small amount of tin and antimony): Hydrochloric and sulphuric acids.

Glass: Strong acids, alkaline liquids.

Earthenware and Gutta Percha: Strong acids.

Strength of Cold-Drawn Steel Bars.—Experiments made recently at the Pennsylvania State College seem to indicate that, for sizes less than 1½ ins. in diameter, cold drawing yields a product that gives results at least equal to those produced by cold rolling. The process of cold drawing (reducing the diameter of a bar about 1-16 in. by pulling it through a die) practically doubles the strength of the bar at the elastic limit, and increases its ultimate strength from 10 to 15%. In all the tests made no appreciable decrease in either the elastic limit or maximum strength occurred as the center of the bar was approached, showing that the compression due to drawing results in decidedly more than a surface finish.

Waterproofing Concrete Structures.—The ordinary method of waterproofing by using a bituminous coating and the one used under a number of conditions is by the application of a priming coat of paint, which has light enough body to enter the pores of the concrete and form an anchorage for the heavier bituminous coat. On top of this is mopped a hot coat of pure bitumen. This coat is of varying thickness, according to the work, from one-sixteenth of an inch on a concrete roof to one-fourth or one-half inch for bridge floors and deep foundations. Where the coating is exposed to the effect of cutting or chipping some reinforcement through the coat or some hard mastic mix is necessary. For vertical structures where the cutting effect is not accompanied by heavy load the reinforcement of the coating by the application of a single ply burlap is sufficient. Where, however, the waterproofing is horizontal and there is a cutting load above it is often advisable to use a mastic mix.—"Waterproofing."

The Importance of Sulphur Dioxide in the Atmosphere.—Writers in the past have paid but little attention to the presence of sulphur dioxide in the air. Various diseases of the air passages may be very materially influenced by the presence of this gas, and its effect on the general health of people is undeniable. It has been calculated that for every ton of coal burned in London something like three tons of carbon dioxide are produced or about 90,000 tons per day. At the same time about 2,700 tons of sulphur dioxide are poured into the air. The effect of all this poisonous gas pol-

luting the atmosphere cannot but be prejudicial to the general health of the community. To prevent such fouling of the air in all cities where there is a great consumption of coal, legislation should be enacted, making it a misdemeanor to throw out waste sulphurous gas into the air, and a means should be devised to save the gas which is produced when coal is burned. Many useful applications of sulphur dioxide could be made which would more than cover the cost of its removal from the escaping furnace gases.—From an article by Dr. Theodore W. Schaffer in the "Boston Medical and Surgical Journal."

Malleable Cast-Iron "Steel."—A trade misnomer relating to malleable cast-iron is mentioned by Prof. Bradley Stoughton in the "School of Mines Quarterly." On account of its fluidity such iron may be cast very cheaply in small sizes, and therefore the temptation to use it as a material for "cast-steel hammers," "hard-steel" bevel gears, "semi-steel castings," and even automobile "steel" drop-forgings, is a strong one. It is usual for the manufacturer when putting material of this kind upon the market to qualify the name "steel" with some other letter or name, such as "P. Q. steel"; but they all differ from true steel in that they were not "cast into an initially malleable mass." Some are made by melting a large proportion of steel with cast-iron, after which the cooled metal may or may not be annealed in iron oxide. Others are made by a long or thorough annealing of ordinary malleable castings in iron oxide, by means of which the metal is decarburized to some depth, and is then carburized again by a cementation process. This makes a very good material for some purposes, such as small bevel gears not requiring strength or much ductility, but it ought not to be called "steel."—"Engineering Record."

The Effect of Light on the Eye.—In a recent article in the "Journal fuer Gasbeleuchtung" on "The Effect of Light on the Eye," the authors, Messrs. Schanz and Stockhausen, give the results of recent investigations carried out by them. They state that the eye is affected by artificial light in proportion to the brightness of that light in candles per sq. in. The greatest allowable brightness, which can be withstood by the eye without bad effect, is somewhat more than four candles per sq. in. It is at once seen that all electric incandescent lights are above this limit. In fact, carbon-filament lamps have a brightness which exceeds the allowable limit 100 times, metallic-filament lamps exceed it 270 times, the Nernst lamp 550 times, and the electric arc lamp 4,000 times. All these types of lights should be covered with a diffractive globe, made of glass, so that the ultra-violet rays, which have been found by these experimenters to be objectionable, are absorbed. The only lights which are not above the allowable limit of brightness are oil lamps, paraffine candles and certain types of kerosene and gas lamps. The authors state that electric lights with plain globes should never be used for illuminating work shops or school rooms. Lighting by indirect methods is always preferable.

German Cupola Practice.—In a recent issue of "Stahl und Eisen," Mr. C. H. Jaeger states that the minimum height between the tuyeres and the top of the cupola should be 13 to 20 ft., and that in a cupola of 2 ft. 4 ins. to 3 ft. inside diameter it should not be less than 17 ft. With such practice good regeneration of heat is issured, no flame issues from the top, and economy of fuel results. The following outputs are obtained per hour in Germany, according to the statements of Mr. Jaeger. Cupola 20 ins. inside diameter, 1 to 1½ tons; 24 ins., 2 to 3¼; 28 ins., 3¼ to 4½; 32 ins., 4½ to 6; 36 ins., 5½ to 9; 40 ins., 6½ to 10. If the cupola is of the proper height coke to the amount of 6 to 7% of the weight of the iron will be required to melt the iron. With 7% it is possible to get a finely-fluid machinery iron. The air should be furnished by a blower, preferably rotatory, which should be able to furnish the required amount at pressures up to 40 ins. water gage. The charges to the cupola should be broken small and the shaft should always be kept full. In order to give the blast sufficient velocity to penetrate the charge properly, the nozzle must be small. The velocity varies from 100 to 160 ft. per second, according to the size of the furnace.

Ideal Molding Sand.—The ideal molding sand is a material in which the individual grains of silex, constituting approximately 90 per cent. of the mass, are completely covered with an overcoat of alumina or clay, and the more uniform the grains are in size and shape the better is the sand with respect to porosity in relation to the average size of the grains. In order to obtain the greatest possible uniformity in size of the grains, the sand is fed into a centrifugal sand-mixing machine,

which consists of a rapidly revolving table, having on its upper surface a number of prongs arranged concentrically. The sand is fed into the hopper at the top of the machine, from which it falls upon the revolving table and is thrown by centrifugal force from prong to prong and out against the inside of the cover or hood. It emerges from beneath the hood in a fine shower, free from lumps and thoroughly mixed. The high rate of speed at which the table revolves, from 800 to 1,200 revolutions per minute, causes the sand to be tossed with much force from prong to prong, thus breaking up agglomerated lumps of gravel or clay, insuring not only complete disintegration, but a degree of mixing not attainable by any other method.—A. E. Outerbridge, Jr., in "The Foundry."

The Strength of Wood.—For the past twenty years the effects of moisture, temperature, drying, etc., on the strength of wood, have been made the subject of study by many engineers and scientific societies. The results of the various tests which have been made are summarized by H. D. Tiedmann in a paper recently read before the American Society for Testing Materials. A brief summary of the conclusions reached by Mr. Tiedmann in his paper follows:

(1) Moisture has a great effect upon the strength of wood, which may be increased by artificial drying over four times its original green strength, but in the ordinary air-dry state it is from 1½ to 2½ times as strong. This does not apply to large timbers, but to sticks under 4 inches thick, to which no mechanical injury has occurred in drying.

(2) There is a definite moisture condition called the fiber-saturation point varying from 20% to 30%, beyond which the cell-walls cease to imbibe water, although free water may continue to enter the pores. Here swelling ceases and the strength becomes constant under given conditions.

(3) Soaking wood at uniform temperature does not reduce the strength of green wood, but warming the water does reduce it.

(4) Any kind of drying reduces the strength when re-soaked as compared with that of the original green wood.

(5) Certain methods of drying at high temperatures reduce the hygroscopicity and consequently the swelling and shrinkage; and when in the air-dry condition the strength is increased over that of normal air-dry wood, but when re-soaked it is reduced below that of green wood.

(6) All tests on wood should be standardized at least for moisture, temperature and speed of loading.

Water for Economical Steam Generation.—Definite figures in regard to the saving accomplished by chemically treating natural waters for use in steam boilers, are given by Mr. J. C. Wm. Greth in a recent number of "The Engineering Magazine." He cites two plants, each consisting of four 125-HP. return-tubular boilers, one operating with a natural supply almost ideally adapted as a boiler-feed water, being city water taken from a mountain stream, and the other using well water in order to avoid the expense entailed by using city water. The costs of operation per year (exclusive of fuel used) were $1,183 and $1,094, respectively, based on an evaporation of 4 gals. per hour per HP., 24 hours per day for 300 days. Later, the plant using well water installed a water-softening system, the cost of operation being thereby reduced to $690 per year, including 16% for interest and depreciation on the $2,000 water-softening system. As to the saving in fuel that can be effected, figures are given of a 175-HP. water-tube boiler plant over two periods of five months each, the load in both cases being practically constant. The record for the second period, in which a water-softening plant was used, showed that 22% less coal was burnt than in the first period, in which the water was not treated before evaporation. The treatment in this case reduced the number of grains of incrusting substances per U. S. gallon from 35.68 to 2.66.

The Ratio of Heating Surface to Grate Surface as a Factor in Power Plant Design.—At a recent meeting of the American Institute of Electrical Engineers, Mr. W. S. Finlay read a paper on this subject, discussing the effect of varying the area of the grate. The writer described an interesting change which was made in the design of eighteen of the boiler furnaces in the Fifty-ninth Street station of the Interborough Rapid Transit Company. A second stoker was installed under each boiler. This had an area of 80% of the area of the original stoker. By this change the output of the boiler was considerably increased, although the efficiency remained the same. A saving in boiler room area results from such a change and, in consequence, a number of other factors in the cost of installa-

tion. The author estimates that by the use of the double-grate instead of the single-grate system the cost of the boiler house may be reduced about 40%, the cost of boilers reduced 50%, that of the piping about 40%, and that of the coal-handling apparatus about 15%. In the case which he mentions the total cost per kilowatt of station output was reduced from $125 to $101.50, a saving of 19%. From this he calculated that a plant with single-grate equipment, costing $150 per kilowatt, a saving of about $31 per kilowatt, or 20.8%, could be effected by the use of the double-grate system.

The Density of a Pavement a Factor in its Durability.—It is an axiom in many branches of engineering that density increases the stability and durability of structures. This applies to pavements which must resist the pressure and attrition of that which comes in contact with them. The pressure and shock of wheels of vehicles and hoofs of horses are best resisted by a concentrated dense mass. This applies to each kind of pavement and helps not only to determine what kind of pavement will best resist a known or estimated quantity and weight of traffic, but also to select the best blocks among any of the following groups: granite, basalt, trap, wood, brick or asphalt. Density is an important quality in all composition pavements, laid in monolithic or sheet form, such as asphalt, bitulithic, etc. That which is densest (other elements, as proper materials, mixtures, etc., being equal) is to be preferred. The same reasoning applies to all other kinds of pavements; different bricks, woods, etc., proposed for paving. Requirements of minimum density for each pavement should be inserted in all specifications in order to secure, in conjunction with other requirements, the best possible pavements. Laboratory tests, combined with observation of the results in actual pavements in use produce definite numerical requirements of density which can be inserted in pavement specifications.—J. W. Howard, in a paper before the American Society of Municipal Improvements.

Diamond and Carborundum Crystals in Steel.—The "Zapiski Imper. Rousskago Technitcheskago Obchestva" during the months of July and August, published an interesting communication from M. Tchernof to the Imperial Russian Technical Society, in which the author calls attention to his researches and publications between the years of 1867 and 1878, regarding certain crystals found in hexagonal flaws of a small ingot of steel. The author decided at that time that these crystals were probably diamonds. The article continues with a correspondence between the author and M. Osmond, carried on between 1900 and 1902 on the subject of these crystals which had been the subject of research on the part of the latter scientist after he had received an ingot of steel already examined by M. Tchernof. The same crystals have also been described by M. Franck, of Berne, and are considered by him to be diamonds. Others, on the contrary, hold the view that they are carborundum, and the question of their chemical composition does not seem to be entirely clear as yet. The points in favor of both views are summed up by M. Tchernof in the article. The author concludes the discussion with a few words on the manufacture of diamonds by the process discovered by Moissan, which consists in dissolving carbon in molten iron at a very high temperature and in making it crystallize by cooling at a very low temperature.

The Effect of Mica on Concrete.—Recent tests made in the laboratory of the South & Western R. R. show the decrease in the strength of mortar or concrete when the sand contains an appreciable amount of finely powdered mica. In many parts of the country, especially in sections of North and South Carolina, Tennessee, Virginia and Pennsylvania, the sands contains much mica, the coarser containing from 3% to 4% and the finer containing from 10% to 15%.

These sands show an increase in voids as well as a decrease in strength. The increase in voids alone will decrease the value of the sand for concrete, while the surfaces of the mica are slick and do not make a good bond with the surrounding cement. Sand which contains 20% mica requires three times the amount of water for mixing as the same sand without mica.

The mica used in these tests ranged from 2.45 to 2.60%, averaging 2.55%, and was ground until all passed a No. 10 standard sieve, 29% a No. 20 sieve, 10% a No. 50 sieve and 4.5% a No. 100 sieve, making it as near as possible like the mica in the natural sand.

One series of tests was made, using Ottawa sand and another with Pittsburg crushed quartz. All mixtures were made of one part cement to three parts sand or sand and mica. The tests showed a decrease in tensile strength of 30 to

60%, according to the proportion of mica, which ranged from 2½ to 20%, for briquettes six months old. Briquettes a year old showed a still greater decrease in tensile strength, when compared to specimens made with sand containing no mica.—W. N. Willis in "The Engineering Record."

Cellulose Acetate for Wire Insulation.—Owing to the fact that silk, when used for insulating copper wire, is expensive, and that cotton occupies a large proportion of the winding space, many chemical substances have been tried as substitutes. Cellulose acetate and enamel have proved to be the best thus far tried. The mechanical properties of this substance make it a desirable substance for insulating, especially when used for very fine wires. It is elastic and can be stretched considerably before rupture takes place and its resistance is very high.

The wires to which cellulose acetate is particularly adapted as an insulating agent, are very fine wires, such as 0.003 to 0.005 in. in diameter. For larger sizes the enamel coating is more suitable. The advantages of cellulose acetate over silk and cotton, where used to insulate wires for winding coils, are shown in the following table:

COMPARISON OF COILS WOUND WITH WIRES INSULATED WITH CELLULOSE ACETATE, SILK AND COTTON.

Diameter of Spool..... 1 in.
Length of Spool..... 1 in.
Number of Turns.....100,000
Diameter of Copper..... .003 in.

Insulation of Coil.	Outside Diam. of Coil. (ins.)	Resistance. (Ohms.)	Wt. of Coil. (lbs.)
Acetate	.....4.20	78,300	2.22
Single Silk	.5.53	89,500	3.04
Single Cotton	.9.50	144,000	6.73

—Condensed from an article by R. Fleming in the "General Electric Review."

Belt Electricity.—In a recent issue of the "Chemiker-Zeitung" Prof. M. M. Richter contributes an interesting article on "Belt Electricity." He attributes many explosions which have taken place in various industries to the production of high static charges upon the machinery bands. This appears to be particularly the case when resinous products are placed on the belt. Experiments were made with a 5¼-inch broad belt which could be drawn over a wheel going at 600 to 2,000 revolutions, by means of a motor. Potential measurements by means of an electroscope showed that in the middle of the belt a P. D. of 13,000 volts existed. On discharge a spark of from 1 to 1⅛ ins. was obtained.

The dryness of the belt and of the atmosphere and the speed at which it was driven effected the P. D. With a belt 1⅝ ins. wide, when it passed over the pulley 18 times in the minute, the P. D. in the centre of the strap was 1,800 volts. Running the belt loose or tight did not affect the voltage of the static charge produced. It is obvious that, in works in which the atmosphere is dust laden or contains vapors of oils, etc., which, when mixed with air, become explosive, dangerous explosions may be produced by discharge of the static electricity in the belt.

Experiments were tried to prevent the formation of such charges by coating the belts with bronze or aluminum powder; it was, however, found that the effect was unsatisfactory. However, the author found that if glycerine, which must be acid free, is smeared over the belt, the hygroscopic nature of the substance keeps the belt moist and prevents the formation of static charges. The best mixture is one part of glycerine and one part of water; this can be put on with a sponge as the belt passes round, and should be renewed weekly. A further advantage is that the glycerine increases the life of the belt.

Fog and Its Mitigation.—In a recent article in the London "Times Engineering Supplement," Sir Oliver Lodge makes some interesting suggestions as to methods of preventing and dispersing fogs. He states that fogs in cities are largely due to the presence of deleterious gases in the atmosphere, such as carbon and sulphur dioxides as well as tarry and other products of the distillation and incomplete combustion of coal. By proper regulation of coal consumption, such as improved fire-places, intelligent stoking, special boiler appliances, etc., much can be done to prevent the throwing out of these noxious and fog-producing gases. The author, however, suggests the following method, which has, at least, the advantage of novelty: "The real and ultimate remedy is not to allow the importation of coal at all into a large town, but to have it converted into partially purified gas outside. It would thereby become possible to do away with the conveyance, by road or rail, of fuel in the solid form altogether; and to depend upon the flow of gas through pipes laid down for the purpose. The gas could be made at the coal-pits without any locomotion of coal. It can be made in such a way as to economize the

valuable products of distillation, and to give a useful kind of coke; and then the non-illuminating heating gas thus provided, after such a minimum of purification as may be thought sufficient, can be forced along immense mains to the distant towns, just as water is now supplied." The above suggestions deal with the matter of prevention of town fog. Country mists and sea fogs, he believes, may be due to the electrification of the atmosphere. Normally the air is negatively charged, but when the atmospheric potential becomes positive, the result may, according to the author, be a condensation of the moisture present. He suggests the discharge of high-tension electricity of negative sign, into the air on a large scale. This may possibly have the effect of dissipating fog. In a small laboratory experiment it had the effect of condensing smoke into black snow and mist into rain. What the effect of such discharge on a large scale would be cannot be predicted, but it will surely be tried before long.

Water Treatment with Barium Salts.—On the question of water softening, it has been pointed out that whereas lime could be best used for reducing temporary hardness, the use of soda to reduce permanent hardness involves the production of sodium sulphate, which remains in the water, being very soluble, until it concentrates to the point of crystallization. It was, therefore, suggested that a barium salt might be employed. Barium carbonate is insoluble, and so is barium sulphate. Now, by putting barium carbonate into a water rendered hard by lime sulphate, the barium and the lime will exchange acids, the lime sulphate becoming a nearly insoluble lime carbonate, and the barium carbonate becoming an equally insoluble sulphate. Both products precipitate and leave a water practically pure. It is claimed that the barium carbonate, though not soluble, can be acted upon by the hard water to this effect, and that as it is insoluble, no care is needed in correctly proportioning the amount of the added reagent. Barium hydrate, which is soluble, may also be employed. This salt will also decompose lime sulphate with the production of lime (CaO), and this lime will serve to reduce any lime bicarbonate to the extent of the proper equivalent. The only bar to the use of the barium salts at present, apart from their poisonous qualities, is that they are too costly. It is expected that by electrolytic means the carbonate or hydrate of barium may before long be made so cheaply as to enable the salts to take the place of soda in water-softening, with the above advantage, that the water will be really cleared of its salts. The soda process for gypsum water is well known to leave a greater weight of salt in solution than was present before softening, with the difference that the new ingredient may concentrate very considerably before it deposits, and the concentration point will rarely occur with care and attention. All the soda salts are so soluble that there is no means of removing them from solution except by concentration. The treatment with barium should come into use if barium salts can be produced at a cheap rate.—"The Electrical Review," (London).

Investigations on the Rusting of Iron.—The results of recent investigations carried out in the Kgl. Technische Hochschule in Munich by Messrs. A. Schleicher and G. Schultz, regarding the rusting of iron, are recorded in a recent issue of "Stahl und Eisen." The experimenters started out to find whether wrought or cast iron was more easily attacked. Two plates were taken, immersed in water, and made to form part of a circuit with which a galvanometer was connected. In the first series of experiments two rusty plates of wrought iron were used. On immersion the voltage steadily rose for some minutes and then fell to zero after ninety minutes. Cloudy streams were observed flowing down from each plate at the end of an hour, and at the end of thirty minutes more, the two streams, which had flowed together, rendered the whole liquid turbid. It was at this time that the zero voltage was attained. In the second test two clean plates formed the couple. The voltage rose at first and then fell below zero, indicating that the poles had become changed. The voltage then rose steadily for some time, but never reached as high a point as that attained by the rusty plate couple. When the couple consisted of one rusty and one clean plate, the latter remained the cathode throughout the duration of the experiment, so that the voltage was always below the zero point. These results are taken by the experimenters to indicate that the process of rusting is an electrochemical one. If the voltage remains constant the two plates are undergoing the same amount of change; if, however, the voltage changes, one plate is undergoing more rapid change than the other.

In addition to the above tests the experimenters made investigations on the amount of iron dissolved from cast and wrought iron

shavings of different compositions, which were subjected to the action of water and carbon dioxide. The results showed that cast iron was more liable to rust than wrought iron. The same conclusion was reached when the shavings were exposed to the action of water, air, and carbon dioxide. No results were obtained, however, which would lead to show what effect, if any, the percentages of carbon, silicon, etc., contained in the iron, have upon its liability to rust.

Tests on Concrete for Heat Resistance.—A number of interesting tests were recently made in the power house of the West Penn Railways at Connellsville, Pa., to determine the adaptability of concrete for use in the construction of smoke flues. The tests were conducted by F. W. Scheidenheim, construction engineer for the company.

In the first test five specimens were made, each 6 in. × 6 in. × 3 in. with a 6 in. × 6 in. piece of 3-in. mesh, No. 10 gage expanded metal placed ¼ in. from the bottom. One of these was made of three parts sand and one of cement. The others were made with three parts of sand and cement and lime in varying proportions to make up one part at the end of two weeks. The specimens were put in the back of a boiler at the power house, directly above the flue, where they received the heat from the flue gases just before the gases pass into the smoke-flue. They were exposed to heat for approximately 84 hours. The temperature was about 800° F. at the end of the test. The specimen made without lime showed no appreciable deterioration as to hardness. A small crack, however, appeared. The specimens made with lime softened appreciably.

In the second test two specimens were exposed to heat under same conditions as the specimens described above. The specimens were 12 in. × 12 in. × 3 in. with a similar piece of expanded metal placed about three-quarters of an inch from the bottom. One specimen contained sand, cement and cinders in the proportion of 1, 2, 4; the other contained lime, sand, cement and cinders in the proportion of ¼, ¾, 2, 4.

At the end of the test block No. 1 was slightly cracked; otherwise it was sound and hard. The cracks seemed to extend nearly through the whole block. Block No. 2 had surface cracks only, but was very much softened, as was discovered by tapping with a sledge. The cinders in both blocks showed some signs of burning, although this did not seem to have affected the block. Mr. Scheidenheim concluded, however, that this tendency to burning was sufficient to condemn the use of cinders in making concrete for flues. The tests also showed the weakening effect of lime when used in places where the concrete was subjected to heat.—Condensed from "The Street Railway Journal."

Breathing Apparatus for Use in Mines.—Owing to the dangers attendant upon working in many mines, particularly after explosions, breathing apparatus of various kinds have been devised. The essential requisites of such devices are: (1) To allow the wearer to remain in an irrespirable or poisonous atmosphere for some time, and (2) to allow a man to crawl through or under such obstacles as may be encountered after a mine explosion, with the same ease as an unencumbered man. These objects are attained by connecting the mouth with a breathing bag or box, into which oxygen is delivered, and from which the exhaled carbonic acid is absorbed; by making and arranging the required apparatus so that it is as light as possible, and is adapted to the body in such a way as to unfetter the movements of the wearer, and to increase the girth of the body as little as possible. The apparatus, too, must not project in such a way as to dislodge beams, rocks, etc., when the wearer is exploring dangerously encumbered ways after an explosion. The apparatus should fit him so that he knows he can pass through where his head and shoulders can pass. The apparatus must be air tight from without inwards to prevent the entrance of irritating vapors, such as thick smoke, and the eyes must be protected from the same. The apparatus should allow of the mouthpiece being removed so that a few words of direction may be spoken or drink taken if occasion arises. There is no risk in doing this so long as the tube leading from the mouthpiece to the breathing-bag can be closed by the thumb.

The breathing-bag must be large enough to contain the deepest inspiration or expiration quite easily. Inspiration out of an empty, or expiration into a full bag is very distressing and not free from risk. The breathing volume while resting is about 30 cu. ins.; while working it may reach 90 cu. ins. The bag must be moderately distensible.

The carbon dioxide is absorbed from the respired air by sticks of sodium hydroxide placed at the bottom of the breathing-box or bag. The oxygen is supplied from bottles which are

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strapped on the back of the miner. These are filled with the gas under pressure. The supply is sufficient to deliver about two quarts of oxygen per minute, and the supply is sufficient to last about two hours. A pressure gage is attached to the front of the breathing-bag and the miner can see at any moment how much longer his supply of oxygen will last.—From a lecture delivered by Prof. L. Hill before the North Staffordshire Institute of Mining and Mechanical Engineers.

Treatment of Decayed Stone.—When the decay of stone has been caused, or partly caused, by the attack of sulphuric acid, baryta may be used to remedy the trouble. The easiest way of applying this earthy base is in the form of baryta water. This is a solution in distilled water of barium hydroxide. A solution saturated at the summer temperature is used in the following manner: Dust and loose particles of stone should be removed from the surface to be treated by means of a jet of air, although there are cases where the stone may be safely cleaned by means of a dry brush. Then the baryta water should be applied in the form of spray to the surfaces of the decayed stone, the use of a brush of any kind, at this stage, being generally inadmissible. The spraying should be repeated, at intervals of two or three days, until the treated stonework has become hard enough to bear the application of a paint brush freely charged with baryta water; in some cases a garden syringe having a fine rose jet is a convenient instrument to employ. For all external stonework and in all interiors not artificially warmed, the baryta treatment must be carried out in the summer, preferably in dry weather. The baryta solution, which penetrates to a considerable depth in the case of porous stones, seldom hardens the surface appreciably until it has been applied several times; eight or nine applications are sometimes required. Roughly, one gallon of baryta water serves for a single treatment of twenty superficial yards.

Several cautions must be given as to the carrying out of the baryta treatment. Baryta water being poisonous, the workmen engaged in applying it must be told of the necessity of washing their hands before eating. And as the fine spray is liable to be inhaled, it is advisable for the men to place occasionally on the tongue a crystal of sulphate of soda and to swallow the solution formed; thus any soluble barium compounds in the mouth are changed into the insoluble and harmless sulphate. The baryta water must not be exposed more than can be helped to the air, as its strength, and in consequence its efficacy, will be impaired by the absorption of carbonic acid, which causes a precipitation of the carbonate. Then, too, the baryta water must not be allowed to cool below 60° F., or it will be weakened by the separation of crystals of barium hydrate.—Condensed from an article by A. W. Church in the "Stone Trades Journal."

Preservation of Steel Imbedded in Concrete.—In tearing down a one-story reinforced concrete building erected by the Turner Construction Co. in 1902 for J. B. King & Co. at New Brighton, Staten Island, Mr. H. C. Turner, the president of the erecting company, was able to discover much in regard to the stability of this kind of construction. The account which he has prepared goes far toward proving that under ordinary conditions of loading and location and with proper precautions in building, reinforcing steel thoroughly embedded in concrete will remain free from rust.

The portion of the building removed had an area of 30 × 60 ft. and was razed to make room for a five-story structure. Owing to the extreme hardness of the concrete, 16-lb. sledges were used to knock holes through the roof slab, and when once a large hole was formed it was an easy matter to continue the wrecking.

The walls were pulled over by block and fall and showed very clearly the elasticity of the wall. These walls were anchored to the footings by bond bars which had been placed with the footing. Before falling the wall would lean at least 20° from the vertical and remain intact. The columns after being cut free at the top would bend back and forth like a sapling before the vertical bars would break. These bars finally broke at the junction between the footing and the column, permitting the entire column to fall over unbroken.

All steel reinforcement was found in perfect preservation, excepting in a few cases where the hoops were allowed to come closer than ¾ in. to the surface. Some evidence of corrosion was found in such cases, thus demonstrating the necessity of keeping the steel reinforcement at least ¾ in. from the surface. The footings were covered by the tide twice daily. The concrete was extremely hard and showed no weakness whatever from the action of the salt water. The steel bars in the footings were perfectly preserved, even in cases where the concrete protection was only ¾ in thick.—"Engineering News."

BOOK DEPARTMENT

THE VALUE OF ENGLISH TO THE ENGINEER

By H. P. BREITENBACH*

The function of the study of English in the training of the engineer and its contribution to his success in life are arriving at a measure of appreciation. Many engineers, in the technical press and elsewhere, have expressed noteworthy opinions as to the importance of the subject. One engineer of prominence writes: "Regarding the degree of proficiency in the use of English needed by an engineer, I can hardly express myself in sufficiently strong terms." Says another: "English has been of more value to me in the practice of engineering than any other study." College faculties, to be sure, have long held similar opinions. Thomas M. Drown, when president of Lehigh University, thus expressed himself when writing on the subject: "Too much stress cannot be laid on the importance of a thorough course in English language and literature. This should begin in the primary school and be continued without interruption to the senior class of our colleges and engineering schools. It is, if possible, more important even that the engineering student should be proficient in the writing of English than the collegian. The ability to express himself clearly and accurately may be said to be a tool of his trade, for he has to write reports and prepare specifications, the very soul of which is accuracy." Even among students in engineering colleges there are signs that their old-time intolerance of English as "not practical" is giving way to a fuller conception of its meaning and a realization of its true value for them.

The movement toward appreciation of the value of English as a college study is no doubt due to a more fundamental conception of the nature of the subject. It has been too commonly assumed that the ideal of language is correct grammar; or that its main element is the study of "figures of speech and other ornaments of style." At the bottom of these notions, and possibly responsible for them, is the shallow theory that makes rhetoric a matter merely of form, with no concern for, nor relation to the content or meaning. Corresponding to this attitude toward rhetoric is the equally shallow view of literature as designed for mere amusement or pastime.

The broader and deeper conception of language and literature relates them intimately with mind and with life itself. It accords with the established doctrine that thought and language are inseparable; as one of the profoundest thinkers of modern times has expressed it, "It would be rash to say that there can be thought without language—if language includes every possible system of recognizable signs—and wholly perverse to imagine that the ideal of intelligence is at all in the direction of a severance of thought from words." The teacher of rhetoric and composition, accordingly, is no longer satisfied with an essay whose merit consists in correct spelling, punctuation and grammar. He recognizes that, while these things have their importance, it resides not in themselves, but in what they represent. The teacher goes back of the words to the ideas for which they are symbols. His task, as he conceives it, is not to teach the student to put words and sentences together like building-blocks, but rather so to train his powers of observation and analysis and so to develop and organize his powers of thought that clear and accurate expression will be the natural accompaniment. The corresponding view of literature regards it as a representation of life; its study is the endeavor to interpret the experience of others in terms of one's own experience.

Considered in this light, the study of his language and its literature, it is readily seen,

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will form an increasingly large part of the education of every successful professional man. With the maturing of his powers he will draw more and more upon the stores of knowledge which the race has accumulated in the form of literature; and correspondingly, too, he will extend his own range of influence through the expression of his ideas. For the engineer, the two main media of expression are the drawing and the spoken or written word. As he advances in his profession, the latter becomes increasingly important. As one engineer puts it, "The big work of the engineer is done with the typewriter rather than with the slide-rule or T-square."

For the student in the engineering college the study of English is very often the sole representative of the cultural as distinguished from the technical or professional element in his education. As such it opens avenues of approach into the literature of science, history, art and other subjects, from which he may gain a fuller knowledge of the world and of the part he should play in it. Recognizing the opportunity here afforded, several engineering colleges lay out for the student prescribed courses of general reading, with the idea, as one school announces, that his acquaintance with this literature "will not only increase his general usefulness and his individual enjoyment, but will also be of much practical importance to him as a professional man in his social and business relations." Other benefits also are, of course, to be derived by the engineering student from the study of English; these, as President Drown intimated, are such as the average collegian derives from the same source.

Once graduated and entered upon his profession, the engineer finds the cultural element of still greater importance. If he is not to confine himself to the routine of his work and the limits set by its interests, if he is to appreciate good literature, if he is to converse intelligently and on equal terms with those whom he meets in social intercourse—if, in short, he is to be a citizen of the world and not merely a worker in it, he needs to share in its culture.

It is, however, mainly the practical benefits arising from training in English that the engineer has recognized. On this point his own testimony may well be presented here. A year or two ago, as an outcome of a discussion that arose in an English class of junior engineers at the University of Michigan, the members of the class were encouraged to write to alumni of the department to secure their opinions on certain points at issue; among these was the question of the value of English to the practicing engineer. About a half hundred replies were received. The writers of all of them agreed in ascribing to English a high value among the engineer's assets. They mentioned as the chief professional applications of the engineer's training in the subject—in addition to the furthering of his command of speech—the writing of business letters, articles for the press, reports, contracts and specifications. Moreover, several cases are cited of engineers who have made writing their lifework, devoting themselves, that is, to the fields of catalogue and advertisement writing, technical journalism and the like.

The influence of his speech on the success of the engineer is too often lost sight of. By the instructions he gives his subordinates, by his conversations and discussions with his fellow engineers, and by his attitude toward those that seek his advice, especially when he has to address himself to an audience of some size, such as a board of directors, a learned society, or a meeting of the general public—by such means and in such cases his professional reputation and success are increased or diminished. When he appears in court as witness, says one of the chief authorities of the country on the legal aspect of engineering, he is apt to be unsuccessful "because of a lack of prompt comprehension of the English language."

The ability of an engineer is often judged by the business letters he writes. Certainly they in great measure determine his success. The well-written letter of application secures for him the desired position. The courteous answer to an inquiry leads to desirable business relations. A careful explanation of some matter misunderstood, or a tactful treatment of some point at issue may prevent the loss of a desirable client or customer. "Correspondence," as one engineer writes, "is in itself a fine art, and is of extreme importance."

When the letter is addressed to a technical journal or when an article is written for publication, even more important results may ensue. Immeasurably wider circles of influence are thus opened to the individual. To an article or communication written for a technical journal, more than one engineer can ascribe a rapid rise in his profession. The indifferent or careless engineer reasons that the editorial revision of his letter or article

will straighten out its tangled logic or its confused statements. It is true that the editor's blue pencil does so much and more, in innumerable cases. Any editor of a technical journal will bear feeling witness to that. Indeed, regarding the literary deficiencies of the contributions of many engineers, he will wax positively pathetic. Moreover, the periodical itself generally, despite his valiant editorial labor, will afford eloquent testimony. Yet the standard of the engineering journals is rising, and for the editorial columns of some of them one need feel no shame. Moreover, the increasing number of new periodicals and the enlarging circulation of the old ones are evidence that the engineering profession is coming to a fuller appreciation of the enormous importance to them of these organs of communication. The time is coming—there are even signs that it is close at hand—when indifferent or careless contributions will receive no welcome from the higher class of technical journals. So much the poorer chance will there be for the less capable engineer, and more than ever will individual merit find its opportunity.

The reports, contracts, specifications and other technical documents prepared by engineers exhibit no less the value and need of efficient training in English. The air is full, so to speak, of complaints about inaccurate descriptions, ambiguous expressions, loosely-worded clauses, unsystematic arrangement, etc., etc. It is no exaggeration to say that millions of dollars have been spent in litigation solely because of such defects. Indeed, a single case involving $4,000,000 might be cited in which the issue is the reference of a relative pronoun. Another case, which was compromised by the payment of $300, hinged upon the mistake of inserting a comma where there should have been none. On the margin of difference between what specifications say and what they are meant to say, tricky contractors grow rich. Cases have been cited, nevertheless, where defective clauses in specifications have not only been used time after time by the author, but have been copied by other engineers into their documents. On the other hand, the carefully prepared reports, contracts, and specifications of many engineers are a credit to the profession, and, in the long run, a source of substantial benefit to all parties concerned. For example, a consulting engineer records the promotion of an assistant to a position "ten times the magnitude of his former job, very largely because of the completeness and succinctness of his monthly reports." Accurate and complete specifications and contracts are of inestimable assistance to the honest contractor and the principal; ultimately, therefore, to the engineer himself.

Besides the above-mentioned ways in which engineers have found English of value, there are certain others of a specialized character. In these a knowledge of language, it appears, is of still greater importance. The reference is to such fields as the writing of technical catalogues, pamphlets and other advertising matter, and the editing of technical journals; all of which employments are comparatively recent specialties for engineers.

Engineering journalism may be called a product of the last half-century, and has only of late years offered desirable openings for engineers. Many of its important positions have been held by men of journalistic rather than engineering ability; on the other hand, many editors today are engineers but are deficient on the journalistic side. The editor of one of our leading engineering journals, in a personal letter, declares that there is but a "relatively small number of technical journals in this country that consider it important to have a thoroughly competent staff." He specifies as the essential editorial qualifications, "besides technical knowledge, literary aptitude; a keen eye for the news value of everything—technical, industrial, financial or otherwise—which transpires within the particular field of a journal; a faculty for discriminating between essentials and details and for presenting a subject impartially and in proper perspective; and a disposition to entering into and maintaining good relations with men in order to command sources of journalistic information. To one who possesses or can acquire these qualifications," he adds, "technical journalism offers a good career." Evidently the rising standard of the technical press is making increased demands not only, as mentioned above, on the contributors, but also on the editors as well. So much, in fact, is definitely set forth in a recent editorial in "Engineering News." Therein the writer asserts that the greatest need in engineering literature today is for better quality. In his illuminating discussion he appeals "as much for high standards of editorial work as for greater care on the part of contributors." Without doubt, the engineer of the future, with his increased capacity for expression in English, and possibly with special uni-

versity training in journalism, is going to respond to the already voiced demand for better technical editors.

To say that engineers are becoming conscious that they constitute a profession and that they are becoming aware of the implications thereof is, in a sense, to sum up the whole matter. As a professional man, the engineer must needs share in the culture of the world; and of this larger life of humanity the English language and literature embodies an important part. His enlarged relations with mankind are reflected in increased requirements for expression. As an applied scientist whose objective point is "the use and convenience of man," he must make his knowledge humanly serviceable, not only by embodying it in structures and machines, but by extending the range of it as knowledge. In the inspiring words of the great historian Mommsen, "The art of measuring brings the world into subjection to man; the art of writing prevents his knowledge from perishing along with himself: together they make him —what nature has not made him—all-powerful and eternal."

BOOK REVIEWS AND NOTICES

ECONOMICS OF RAILWAY OPERATION.—By M. L. Byers, Chief Engineer Maintenance of Way, Missouri Pacific Railway. New York: The Engineering News Publishing Co. London, England: Archibald Constable & Co., Ltd. Cloth; 6 × 9½ ins.; pp. 672; with many diagrams, folding tables and text illustrations. $5, net.

The literature of railroading has been measurably enriched by this effort of a practical man to produce a practical book on the science of railroad operation. He has succeeded to such an extent that his work will, without doubt, be regarded for many years as the standard on its subject, just as for many years Wellington's "Railroad Location" has been regarded as the standard in its field.

The general objects of the "Economics of Railway Operation," as stated by the author, are (1) to so outline the operations of each department as to give to those not familiar with its workings a sufficient insight to enable them readily to acquire further detailed information through their own observations, and through their ability to inquire intelligently in regard to those features which they do not understand. (2) To bring into clear relief the underlying principles of economic operation with a view to the practical usefulness of this information to the employee in securing better results in that portion of the field under his direction; also to give him a clearer general understanding of the science of railroading, and so fit him for further promotion.

The book is divided into seven parts: I., Organization (66 pages); II., Employment, Education and Discipline of Forces (30 pages); III., Accounts and Accounting (54 pages); IV., Reports (65 pages); V., Economic Operation (360 pages), subdivided into six chapters on General Expenditures, Maintenance of Way and Structures, Machinery Department Operation, Transportation, Freight Traffic Department and Other Departments; VI., Analysis of Operations and Control of Expense (52 pages); VII., Betterments (45 pages). Seven pages are devoted to a comprehensive double-column index.

The most important and valuable parts are the first, second and fifth. Under Organization the author has endeavored to give a general discussion of the principles of organization and the objects to be achieved thereby. He lays down several useful rules and quotes at length from the report of a committee appointed by the British Secretary of State for War to consider the decentralization of the War Office business resulting from the breakdown of that department in the Boer war. The difference between divisional and departmental organization is indicated, together with the relative advantages and disadvantages of each. An ideal organization stating in considerable detail the duties of the principal positions on a railroad is given, this Organization being based very largely on that of the Pennsylvania Railroad.

In the second part the subject of the employment, education and discipline of employees is discussed with a view to illustrating the underlying principles and the objects to be attained. Statistics showing the number of railroad employees of the different classes in the United States are given; also, information in regard to employees' Relief Associations, Railway Relief Departments, Railway Savings

and Insurance Departments, and other means for caring for the interests of the employees, are shown.

Under the head of economic operation, the author lays stress on the necessity of obtaining a proper sense of the relative importance of the different items making up the operating expenses. The various details of the expense account are discussed and illustrated, with examples from different railway systems. This part constituting, as it does, more than half of the book, is a valuable treatment of economical operation and is in itself sufficient to give the book a wide circulation and to warrant its consideration as a "standard."

In the sixth part is given a careful analysis of operations and control of expenses, the difference is shown between constant expenditures, which do not fluctuate with any ordinary changes in the amount of traffic; Indirect Variable Expenditures, which, while ultimately fluctuating with the amount of traffic, do not necessarily at the time, show any effect from such fluctuation, and Direct Variable Expenditures, which fluctuate immediately with fluctuations in the amount of traffic. This is followed by a discussion of the General Balance Sheet and General Income Account; the duties of an inspector of transportation and some examples of the inspector's work and the kind of reports to be made. It is impossible for the General Officer of a large railway system to obtain by personal inspection the information needed by him to keep in touch with the operations under his charge, and this condition has necessitated the securing of various reports to supplement his observation. The author here endeavors to illustrate the method of using these reports and the principles upon which their arrangement must be based. Incidentally, the illustrations convey considerable information in regard to Railway Operations.

The other parts of the book will bear the criticism of incompleteness. At the same time, it must be remembered that the material available would fill a much larger book than the present one and careful selection had to be made, so that, while the subject of accounting, for instance, receives considerable attention, it is not as full a discussion as the men engaged in this special work would want and is more than is wanted by those only indirectly connected with it.

An ideal subdivision of earnings, expense, material, and other accounts is outlined, the reasons for the subdivision being briefly stated. The system of accounting outlined is in general that of the Pennsylvania Allied Lines, the Rock Island Lines, etc., with the adoption of which the author had much to do.

We must express our highest commendation of the work Mr. Byers has done in the interest of railroad engineering as a whole and we feel sure that there is hardly a man in the railway service who cannot derive much benefit from a study of this book.

RETRIEVAL AT PANAMA.—By Lindon W. Bates, Author of "Project for Panama Canal," "Terminal Harbors, Panama Canal," "Panama Canal, System and Projects," "The Crisis at Panama," etc. For sale by The Technical Literature Co., 220 Broadway, New York City. Buckram; 6 × 9 ins.; pp. 554; 88 half-tone illustrations, maps and diagrams, including 11 double-page plates. $5.

The subject of the Panama Canal is always of interest to members of the engineering profession as well as to the intelligent reading public, among whom there are many widely varying opinions as to how the canal should be built; but whatever may be the personal opinion of readers, it must be conceded that in championing his system Mr. Bates has put forward one of the most impressive discussions yet published of facts as they exist at the Isthmus. The author is a trained engineer of international reputation, whose connection with some of the greatest engineering projects of modern times and whose careful study of the canal problem from its inception to the present time, place him in a position to speak on the subject with an authority that demands consideration. In this book he strongly argues for "Retrieval at Panama," the keynote of the book being contained in the sentence "Before the colossal deficits and the masked evils have shadowed the faith of American people in their ideals, let retrieval come at Panama."

He concedes and shows the importance of the canal, its value to commerce and the necessity of its control by the American people, but he protests against the people who are endorsing and paying for the canal, being kept in the dark as to the true state of things at Panama. He does not blame the President, but does blame his advisers and declares that no feature of the waterway is as the commission presented it. He states:

The international impractical five million-dollar breakwaters have been dropped, as has the international reef-ridden Pacific approach. The expert alinements at the Atlantic terminal

and in the Mindi-Gatun section have been altered. The Ancon-Corozal and Ancon-Sosa dams have been given up, and a Stevens dam substituted. The experts' "mudsilt" has been repudiated for the heart of the dam, and their cutters for the indurated rock excavation.

"Is this," asks Mr. Bates, "the Panama Canal design for whose preparation engineers were summoned from the four quarters?"

Since the publication in the "New York Press" of the original articles which form the basis of the present work, several changes have been made in the plans for the canal in accordance with Mr. Bates' contentions, but only once, in January, 1907, has the commission openly shown consideration for his words. Since then the canal administration has adopted his stipulation for a 1,000-ft. lock, as against the 820-ft. lock in their plans; has widened the locks from 90 to 110 ft.; has revised the estimates of the cost of the work, and has come to the conclusion to abandon the La Boca lock on the Pacific side, moving it back to Miraflores. As an explanation of this important move, it is asserted that the entrance to the canal being placed so far inland would make it easier of defense, while it is confessed that foundations could not be discovered for the original site.

The author presents his own solution of the Panama problem, which he calls simple, natural and cheap:

Under it, by the building of three low dikes, no higher than those that impound the reservoir at Central Park, in one year, and at a cost of less than $1,000,000, the landwidth of the Isthmus could be reduced from the present forty-seven miles to less than sixteen miles. Forty-seven miles to sixteen miles—the distance narrowed to one-third. Would not this augur a living chance for the canal? Would not this hold some valid promise and some possibility of cut costs and cut forces? A year later, by impounding but fifteen feet of water at Gatun, the landwidth can be reduced to the distance between Pedro-Miguel and Obispo, around seven miles. Forty-seven miles in two years reduced to seven, the landwidth cut to approximately one-seventh—the problems, the expenditures, the execution confined to this narrow pass between the hemming waters, what rescue and salvation does it not guarantee?

However much the reader may disagree with the plans advocated by Mr. Bates for the solution of this great problem, it is not too much to say that his book is the most instructive work of constructive criticism of the Panama Canal that has ever been written. It is thorough in its discussions and is written in a readable style characteristic of the author.

THE CHEMISTRY OF GAS MANUFACTURE. —A Practical Manual for the Use of Gas Engineers, Gas Managers and Students. By Harold M. Royle, F. C. S., Chief Chemical Assistant at the Beckton Gas Works. With colored plate and numerous illustrations. New York: The Norman W. Henley Publishing Co., 1908; pp. xv + 328, 8 ½ × 5 ½ ins.; cloth. Price, $4.50.

This books treats of the testing of the raw materials employed in the manufacture of illuminating coal gas, and of the gas produced. Not much space is given to water gas, and none to producer or fuel gas. Processes of gas manufacture are entirely omitted.

Six pages on the preparation of standard solutions are followed by a chapter on the chemical and physical examination of gas coal.

Furnaces are then treated very briefly, while considerable space is given to methods for determining the temperature, and two instruments for the continuous automatic recording of the amount of carbonic acid in flue gases, etc., are described and figured.

The products of "carbonization" or destructive distillation of bituminous coal then receive attention. Among other interesting information, a list of compounds known to occur in coal tar is given which contains the names of 203 substances.

Methods for the estimation of impurities in crude gas and methods for the analysis of materials employed in the purification of crude gas are dealt with very fully. Indeed, the principal value of the book lies in the completeness with which these subjects are treated. Methods for the determination of the lighting and heating value of gas also receive considerable attention. A short chapter on carburetted water gas deals mainly with the testing of the carburetting oils.

An extensive appendix occupying about one-sixth of the entire book contains in extenso the rules of the London Metropolitan Gas Referees for testing gas, including descriptions, figures and directions for use of all the special apparatus employed. Various standard tables of specific gravity, etc., and a fine index conclude the book.

As is to be naturally expected the British character of the book crops up continually.

A few misprints have been noted, for example, on page 99, copperas is called iron sulphide. On page 146 the cylinder is allowed to revivify instead of its contents, and in the next sentence it is made moisture. On page 148 it is stated that Fe_2O_3 will be estimated as FeO, when what is meant is that such Fe_2O_3 will not be estimated at all. Careless or faulty use

of English is frequent as on page 99, line 2, page 105, line 2, and page 149, lines 8 and 12. The calculations and reasoning on pages 149 and 150 appear to the reviewer unintelligible.

This book should be of great use to those for whom it is intended.

The paper, type and binding are very good, and the illustrations are excellent.

MINING, MINERAL AND GEOLOGICAL LAW.—Treatise on the Law of the United States Involving Geology, Mineralogy and Allied Sciences as Applied in Mining, Real Estate, Public Land, United States Customs and Other Litigation; Also the Acquisition and Maintenance of Mining Rights in the Public Domain and Obtaining Patents for Mineral Land Under the United States Mining Laws. By Charles H. Shamel, Ph.D., of the Illinois and Michigan Bars. London and New York: Hill Publishing Co. Cloth; 6 × 9½ ins.; pp. 627; 103 illustrations in the text and 1 folding sheet. $5.

The value of a thorough knowledge of mining law in the equipment of the mining engineer is usually underestimated. The importance of the relation between the laws regarding mining operations and the actual performance of those operations can hardly be overestimated. In the United States mining is liable to be subject to special provisions of three different legal systems, namely, the common law, State statutes and the United States statutes. If a mine is not operated in accordance with these complicated laws, it is likely to become the prey of costly litigation. In the past no book has been available from which practical men could obtain a knowledge of mining law. Recent alterations and revisions of the statutes and court decisions have rendered such as are now on the market untrustworthy, on which account Mr. Shamel's work will be doubly appreciated. The volume is designed for the lawyer as well as the practical man, and covers the entire field of mining law. A concise but thorough discussion of the scientific topics which are important in connection with mining litigation is given in the beginning of the work, and its value is supplemented by an excellent bibliography on these subjects. The author then takes up the questions of property in minerals, and cites the legal definitions of minerals, veins, lodes, etc. The law relating to mining rights on the public domain, and the extralateral or apex law are next thoroughly discussed. The question of tunnels and the tunnel locations is then considered, and many interesting instances of the use of geology in the law are quoted. An extremely valuable appendix concludes the work. This contains the full text of the United States statutes governing mining, the Land Office rules and the mining statutes of all the important metal-mining states. These are all brought down to date and include the additions and revisions of 1907. A useful index concludes the book.

EXPERIMENTAL ELECTRICAL ENGINEERING—And Manual for Electrical Testing. For Engineers and Students in Engineering Laboratories. By V. Karapetoff. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xxxiv + 790; 538 illustrations. $6, net.

In preparing this work the writer aimed to produce a manual for use in the laboratory, which would be suited to the needs of the courses in general electrical engineering which are given in the last two years in most of the American engineering schools. The author first takes up electrical units and the construction and operation of instruments for their measurement. Five chapters are then devoted to the discussion of reactance and resistance in alternating current circuits, electrostatic capacity, the magnetic circuit, permeability tests, and the measurement of core loss. The three following chapters deal with the photometry of incandescent lamps, the arc light and illumination in general. Transmission and distributing lines form the subjects of the next two chapters which are followed by fifteen chapters on electrical machinery and auxiliary devices. In these the various types of motors, generators, converters, transformers, batteries, switchboards and controllers are taken up and the essential features of their construction and operation given. The book closes with four chapters on electric railway work, electric heating and welding, the elements of telephony and the safety of electric plants. The arrangement of the work is such as to make each chapter, as far as possible, independent, in order to enable classes or students to do the work as most suited to their schedule, equipment and convenience. Each chapter contains a number of experiments dealing with the particular branch covered. Altogether there are more than three hundred of them, ranging from elementary to advanced. The plan followed by the author in each chapter is this: first, the particular class of machinery is described and the practical needs for certain arrangements and procedures of operation are given; the object and method of each experi-

ment are next described in detail and instructions as to methods to be employed in obtaining data are given. The book is written in a clear and interesting style and the illustrations throughout are good.

LAND TREATMENT OF SEWAGE.—A Digest of the Reports Made to the Royal Commission on Sewage Disposal by Their Specially-Appointed Officers. By Herbert T. Scoble, Professional Associate of the Surveyors' Institution, M. R. S. I., F. R. M. S. Reprinted from "The Surveyor and Municipal and County Engineer." London: St. Bride's Press. New York: D. Van Nostrand Co. Cloth; 9x11½ ins.; pp. 76. $2, net.

In 1898 the Royal Commission on Sewage Disposal was appointed to investigate the various methods which might be properly adopted for treating and disposing of sewage. Several reports have thus far been made by this commission on various systems for the disposal of waste. The fourth report, made in 1904, contains considerable matter collected as a result of investigations of various sewage farms. These reports are very voluminous, and this digest, by one of the most eminent sanitary engineers of England, will be of value to all who wish to read, in a condensed form, the results of the work of the Commission.

Eight English sewage farms were studied, and the points particularly noted were the following: (1) The composition of the sewage and the preparation before passing on the land; (2) the nature of the soil and the subsoil; (3) figures relating to acreage, population, etc.; (4) method of treatment of sewage and cropping the land; and (5) analysis of the quality of the effluent as compared with sewage and with stream. A digest of the general conclusions of the commission as to the value of the land treatment of sewage are given and the author also sums the results of their work.

WIRELESS TELEGRAPHY FOR AMATEURS.—A Handbook on the Principles of Radiotelegraphy and the Construction and Working of Apparatus for Short-Distance Transmission. By R. P. Howgrave-Graham, A. M. Inst E. E. New York: Spon & Chamberlain. London: E. & F. Spon, Ltd. Cloth; 5 × 7½ ins.; pp. 160; illustrated. $1.00, net.

Wireless telegraphy is each day becoming of more practical value and each day is being used more and more all over the world. Many persons who have followed the development of the system desire to construct one for themselves, but beyond the general accounts given in text-books and articles, have been unable to get any instructions as to methods of procedure. This book is designed to fill this need, and, being written for the amateur, needless technicalities have been avoided and the matter has been presented in as clear a manner as possible. The author first sketches the history of radiotelegraphy and outlines the physical principles on which it is based. A chapter on the Poulsen system for generating electric waves for radiotelegraphy then follows. The next two chapters deal with practical systems for the use of the amateur experimenter, describing the receiving and transmitting apparatus, its construction and its operation. In an appendix the Morse alphabet is given for the use of experimenters who may be unacquainted with it.

MEN WHO SELL THINGS.—By Walter D. Moody. Chicago: A. C. McClurg & Co. Cloth; 5 × 7½ ins.; pp. 296. $1.

The qualifications necessary for the making of a successful salesman and the reasons for so many failures in this branch of business are dealt with in this book. The writer has compiled many of his experiences and observations and he writes not only from the point of view of the salesman, but from that of the buyer, sales manager and employer as well. While the book is not of a technical nature, nevertheless the fact that so many engineers are connected with the selling departments of their firms, and that young engineers especially are lacking in knowledge necessary in this line, will make it one of value to many technical men.

NEW BOOKS.

Civil Engineering.

DAS PROBLEM DER PFAHLBELASTUNG.—By Ottokar Stern. Berlin, Germany: Wilhelm Ernst & Sohn. Paper; 6¾ × 10 ins.; pp. 198; 61 illustrations in the text and 6 plates.

DIE KEGELPROBE.—A New Method of Testing for Hardness. By Paul Ludwik. Berlin, Germany: Julius Springer. Paper; 5½ × 8½ ins.; pp. 35; one text illustration. One mark; American price, 40 cts.

RAPPORT D'ENSEMBLE SUR LES MOYENS EMPLOYES JUSQU'ICI POUR COMBATTRE LA POUSSIERE DES ROUTES.—Presented to the Commission appointed by the Minister of Public Works, by M. Le Gavrian, Engineer of Bridges and Parks, Secretary of the Commission. (Extract from "Annales des Ponts et Chaussées," Vol. II., 1907.) Paris, France: E. Bernard. Paper; 6¼ × 9½ ins.; pp. 24.

MANUAL OF RECOMMENDED PRACTICE FOR RAILWAY ENGINEERING AND MAINTENANCE OF WAY.—American Railway Engineering and Maintenance of Way Association, 962 Monadnock Block, Chicago. Cloth; 6 × 9 ins.; pp. 291; illustrated. $3. (Half morocco, $3.50).

ROAD PAMPHLETS.—By Arthur R. Hirst, Highway Engineer of the Highway Division of the Wisconsin Geological and Natural History Survey. Madison, Wisconsin: The State. Paper; 4¾ × 7 ins.
No. 1: Earth Roads. Pp. 32.
No. 2: The Earth Road Drag. Pp. 24.
No. 3: Stone and Gravel Roads. Pp. 32.
No. 4: Culverts and Bridges. Pp. 54.

STEEL CONSTRUCTION.—A Practical Treatise on the Modern Use of Steel in the Erection of Fireproof Buildings, and Its Applications to Structural Work in General. By Edward A. Tucker, M. Am. Soc. C. E., Architectural Engineer. Chicago, Ill.: American School of Correspondence. Cloth; 6½ × 9¾ ins.; pp. 308; 287 illustrations, mostly in the text. $1.50.

WATER POWER VALUATIONS.—Computation of the Values of Water Powers, and the Damages Caused by the Diversion of Water Used for Power; by Charles T. Main.—Damages Caused by the Diversion of Water Power; by Clemens Herschel.—Water Rights; by Richard A. Hale. (Reprinted from Journal of the New England Water-Works Association, Vol. XXI., No. 3.) Paper; 6 × 9¼ ins.; pp. 214 to 278; illustrated.

Electrical Engineering.

ELECTRICAL TRACTION.—By Ernest Wilson, M. Inst. E. E., Professor of Electrical Engineering in the Siemens Laboratory, King's College, London, and Francis Lydall, Assoc. Inst. E. E. In two volumes. New York: Longmans, Green & Co. London, England: Edward Arnold. Cloth; 5½ × 8¾ ins. $4, net (each volume).
Vol. I.: Direct Current. Pp. 475; 271 illustrations, mostly in the text.
Vol. II.: Alternating Current. Pp. 328; 184 illustrations, mostly in the text.

AN INTRODUCTORY COURSE OF CONTINUOUS CURRENT ENGINEERING.—By Alfred Hay, D.Sc., M. Inst. E. E. New York: D. Van Nostrand Co. Cloth; 5½ × 8¾ ins.; pp. 327; 183 illustrations in the text. $2.50, net.

Mechanical Engineering.

BULLETINS U. S. GEOLOGICAL SURVEY.—George Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.
No. 316 (Extract): General Papers on the Producer-Gas Power Plant, the Coal-Briquetting Industry and Coal-Mine Sampling. With a Bibliography of Geological Survey Publications on Coal, Lignite, and Peat. By R. H. Fernald, E. W. Parker, J. S. Burrows, W. T. Lee and J. M. Nickles. Pp. 439 to 532; one illustration in the text.
No. 334: The Burning of Coal without Smoke in Boiler Plants. A Preliminary Report. By D. T. Randall. Pp. 26.
No. 339: The Purchase of Coal under Government and Commercial Specifications on the Basis of Its Heating Value. With Analyses of Coal Delivered under Government Contracts. By D. T. Randall. Pp. 27.

CARBURETING AND COMBUSTION IN ALCOHOL ENGINES.—By Ernest Sorel. Translated from the French by Sherman M. Woodward, Formerly Professor of Steam Engineering, State University of Iowa, and John Preston. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5 × 8¼ ins.; pp. 269; 26 illustrations in the text. $3; English price, 12s., 6d., net.

DIE ENTWICKLUNG DER DAMPFMASCHINE.—A History of the Stationary Steam Engine, the Locomobile, the Marine Engine and the Locomotive. Prepared at the Direction of the Verein Deutscher Ingenieure, by Conrad Matschoss. In two volumes. Berlin, Germany: Julius Springer. Cloth; 7½ × 10½ ins. Vol. I.: pp. 834; 780 illustrations in the text and 32 portraits. Vol. II.: pp. 732; 1,073 illustrations in the text and 6 portraits. 24 marks; American price, $9.60.

POWER AND TRANSMISSION.—A Work Designed for Elementary Instruction in Colleges and Manual Training Schools. By E. W. Kerr, M. E., Professor of Experimental Engineering, Louisiana State University. Second Edition. Revised. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xiv + 366; 264 text figures. $2.00.

STEAM-TURBINES.—By Carl C. Thomas, Professor of Marine Engineering, Sibley College, Cornell University. Third Edition, revised and enlarged. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 334; folding diagrams and numerous text illustrations. $4.

TABLES OF THE PROPERTIES OF STEAM AND OTHER VAPORS.—And Temperature-Entropy Table. By Cecil H. Peabody, Professor of Naval Architecture and Marine Engineering, Massachusetts Institute of Technology. Seventh Edition, rewritten. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5½ × 9¼ ins.; pp. 131. $1.

THERMODYNAMICS OF THE STEAM-ENGINE AND OTHER HEAT-ENGINES.—By Cecil H. Peabody, Professor of Naval Architecture and Marine Engineering, Massachusets Institute of Technology. Fifth Edition, rewritten. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 533; 117 illustrations in the text. $5; English price, 21s., net.

Metallurgy.

THE METALLURGY OF IRON AND STEEL.—By Bradley Stoughton, Ph. B., B. S., Adjunct Professor, School of Mines, Columbia University. New York: Hill Publishing Co. Cloth; 6 × 9½ ins.; pp. 509; 311 illustrations in the text and 33 tables. $3.

Sanitary Engineering.

AIR-CONDITIONING.—A Short Treatise on the Humidification, Ventilation, Cooling, and the Hygiene of Textile Factories. By G. B. Wilson. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 × 7½ ins.; pp. 143; illustrated. $1.50.

DIE ASSANIERUNG VON KOEBENHAVN [Copenhagen].—Prepared by Messrs. Berg, Bjerre, St. Friis, Gredsted, Heiberg, Hertz, Hoff, Levison, Neergaard, Nielsen (K. M.), Nielsen (H. A.), Nohn, Oellgaard, Schierbeck, Tobiesen and Ulrik, under the supervision of Dr. Th. Weyl. Part 14, Group II., Fortschritte der Ingenieurwissenschaften. Leipzig, Germany: Wilhelm Engelmann. Paper; 7¼ × 11 ins.; pp. 196; 108 illustrations in the text and 21 plates. 15 marks; American price, $6.

KALENDER FUER DAS GAS-UND WASSERFACH.—By E. Schilling, Civil Engineer. Section on Water by G. Anklam, Manager of the Berlin Water-Works at Friedrichshagen. 31st Year, 1908. Munich and Berlin, Germany: R. Oldenbourg. Leather; 4 × 6½ ins.; pp. 284 + 139; 16 illustrations in the text. 4½ marks; American price, $1.80.

MODERN BATHS AND BATH HOUSES.—By William Paul Gerhard, C. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xvi + 311; illustrated with 130 text figures. $3.00, net.

WATER SUPPLY.—By Frederick E. Turneaure, C. E., D. Eng., Dean of the College of Mechanics and Engineering, University of Wisconsin, Madison, Wis. Chicago: The American School of Correspondence. Cloth; 6½ × 9½ ins.; pp. 143; illustrated. $1.00.

Miscellaneous.

A LABORATORY GUIDE FOR STUDENTS IN PHYSICAL SCIENCES.—By H. Schapfer, Associate Professor in Charge of the Department of Physics, University of Arkansas. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 × 7½ ins.; pp. v + 61. $1.00.

ANALYSIS OF MIXED PAINTS, COLOR PIGMENTS AND VARNISHES.—By Clifford Dyer Holley, Professor of Industrial Chemistry, North Dakota Agricultural College, and Chemist on the Staff of the North Dakota Experiment Station, and E. F. Ladd, Professor of Chemistry, North Dakota Agricultural College, State Chemist and Food Commissioner for North Dakota. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5½ × 8 ins; pp. xi + 235; illustrated. $2.50.

A HISTORY OF ASTRONOMY.—By Walter W. Bryant, B. A., Superintendent of the Magnetic and Meteorological Department of the Royal Observatory, Greenwich. New York: E. P. Dutton & Co. Cloth; 5½ × 9 ins.; pp. 355; 35 plates. $3, net.

PRACTICAL PHYSICS.—A Laboratory Manual for Colleges and Technical Schools. By W. S. Franklin, C. M. Crawford and Barry MacNutt. In three volumes. New York: The Macmillan Co. London, England: Macmillan & Co., Ltd. Cloth; 5½ × 8¾ ins. Vols. I. and II., $1.25 net, each; Vol. III. 90 cts., net.

Vol. I.: Precise Measurements.—Measurements in Mechanics and Heat. Pp. 173; 75 illustrations in the text.

Vol. II.: Elementary and Advanced Measurements in Electricity and Magnetism. Pp. 160; 71 illustrations in the text.

Vol. III.: Photometry. Experiments in Light and Sound. Pp. 77; 49 illustrations in the text.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Proceedings of the 15th Annual Meeting, Held in Cleveland, Ohio, July 1, 2, 3, 1907. Vol. XV. Edited by Charles S. Howe, Arthur L. Williston, William T. Magruder. Brooklyn, N. Y.: The Secretary (Pratt Institute). Cloth; 5¾ × 9 ins.; pp. lvii. + 690; illustrated.

Robert C. H. Heck, Professor of Experimental Engineering in the department of mechanical engineering at Lehigh University, and author of a two-volume treatise on the steam engine, has resigned from his chair at Lehigh University after a period of fifteen years in the service of that institution. His resignation followed his appointment to the professorship of mechanical engineering at Rutgers College and will take place in July. The course in mechanical engineering will be offered at Rutgers for the first time next year and the work of organization will fall upon Prof. Heck.

Mark Twain's Typewriter

found to contain useful ideas and valuable suggestions for the home builder and the investor, but for the architect, no matter what his standing in his profession, as well.

DECKER PRIMARY BATTERY.—Decker Electrical Manufacturing Co., 15 Broad St., New York. Paper; 3 × 9 ins.; pp. 12; illustrated.

The Decker primary battery is an electric battery that generates an electric current by chemical action which takes place within its cells. It differs from other primary batteries in the strength and duration of the current produced and in the cost of producing this current. The utmost that any other primary battery can do is to ring an electric bell or run a small fan at a cost of more than five dollars per horsepower per hour. The Decker battery on the other hand, costs about one-twentieth as much and this figure may even be reduced to one-thirtieth. Its advantage is that it can be used where it is now impossible to use other primary batteries, such as running an electric vehicle, a small electric lighting plant, etc. It has the advantage over a storage battery in that it weighs only 50 lbs. per horsepower hour of actual output. The principle on which this battery operates is fully described in the folder which may be obtained from the company on request.

TURNER SYSTEM OF REINFORCED CONCRETE CONSTRUCTION FOR BUILDINGS AND BRIDGES.—C. A. P. Turner, Minneapolis, Minn. Paper; 6 × 9 ins.; pp. 64; illustrated.

This pamphlet, which is bulletin No. 10 of the series issued by C. A. P. Turner and the contractors associated and doing business with him, gives many excellent examples of the "mushroom" system of reinforced-concrete construction, as well as a number of tests made on panels to determine their breaking strength. One of the illustrations shows a panel 16 ft. 4 ins. by 15 ft. 8 ins., loaded with a test load of 90 tons.

RICHARDSON SEAMLESS FIREPROOF DOORS.—I. F. Blanchard Co., Fuller Bldg., New York City. Paper; 4 × 9 ins.; pp. 20; illustrated.

The Richardson fireproof door, which is described in this pamphlet has been tested by the National Board of Fire Underwriters at Chicago for one hour at a temperature of 1,535° F. This and other tests have shown its fire-resisting qualities to be such that the New York Fire Insurance Exchange will give the lowest minimum standard rate on all policies of insurance covering buildings where this door is used in accordance with the types of building construction shown in the pamphlet.

THE HAYWARD "TWO IN ONE" HOISTING DRUM.—The Hayward Co., 103 Cedar St., New York City. Paper; 5½ × 8 ins.; pp. 16; illustrated.

This booklet is published for the purpose of illustrating the applications of the "Two in One" hoisting drum, to various classes of machines. This hoisting drum can be used on dredges, excavators, traveling derricks, railroad excavators, guy and stiff-leg derricks, locomotives, cranes, etc.; in fact, almost every style of machine capable of operating an automatic bucket.

CENTRIFUGAL PUMPS FOR WATER-WORKS AND HIGH PRESSURE FIRE SERVICE.—R. D. Wood & Co., Philadelphia, Pa. Paper; 6 × 9 ins.; pp. 36; illustrated.

This pamphlet illustrates and describes the types of centrifugal pumps manufactured by the company and shows the advantages which they possess over other pumps whether used for high heads in connection with a producer-gas engine, or for low heads and belt-driven.

MOTORS AND ACCESSORIES.—F. A. Brownell Motor Co., Rochester, N. Y. Paper; 6 × 9 ins.; pp. 20; illustrated.

Brief descriptions of the marine, auto and other motors made by the Brownell Co., are given in this pamphlet, as well as a list of parts and accessories. The F. A. Brownell Company is successor to the Brownell-Trebert Company.

AUTOMATIC ELEVATOR GATES AND FIRE DOORS.—Automatic Door & Gate Co., 123 Liberty St., New York City. Paper; 9 × 3½ ins.; pp. 4; illustrated.

This folder illustrates the counterbalanced fire-door manufactured by the company. This door gives the maximum protection against accidents, being closed during the day as well as during the night.

NOMENCLATURE OF MURRAY CORLISS ENGINES.—The Murray Iron Works Co., Burlington, Ia. Paper; 7 × 10 ins.; pp. 24; illustrated.

This pamphlet contains photographs of the various types of the Murray Corliss engines, and drawings in which the nomenclature of the various parts is given.

THE
TECHNICAL PRESS INDEX

220 BROADWAY, NEW YORK

This Index is intended to cover the field of technical literature in a manner that will make it of the greatest use to the greatest number—that is, it will endeavor to list all the articles and comment of technical value appearing in current periodicals. Its arrangement has been made with the view to its adaptability for a card-index, which engineers, architects and other technical men are gradually coming to consider as an indispensable adjunct of their offices.

Each item gives:

1. Full title and author.
2. Name and date of publication.
3. An estimate of length of article.
4. A short descriptive note regarding the scope of the article—where considered necessary.
5. Price at which we can supply current articles.

The Publishers do not carry copies of any of these articles in stock, but, if desired, will supply copies of the periodical containing the article at the prices mentioned. Any premium asked for out-of-date copies must be added to this price.

The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

In order to comply with the many suggestions and requests of readers who desire to make practical use of this index, it is printed on one side of the sheet only, to permit the clipping of any desired items.

LIST OF PERIODICALS INDEXED

JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

Journal Am. Foundrymen's Assn.
Journal Assoc. Engineering Societies.
Journal Eng. Soc. of Western Pa.
Journal Franklin Institute.
Journal West. Society of Engineers.
Proceedings Am. Soc. C. E.
Proceedings Am. Soc. M. E.
Proceedings Can. Soc. C. E.
Proceedings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
Proceedings Pacific Coast Ry. Club.
Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
Transactions Am. Inst. Electrical Engineers.
Transactions Am. Inst. Mining Engineers.

(*Continued on second page following.*)

TECHNICAL PERIODICALS

An inch card under this heading costs $2.50 a month

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The Canadian Municipal Journal

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Brick.
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Bulletin of Dept. of Labor.
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Cement Age.
Cement and Engineering News.
Cement Era.
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Concrete.
Concrete Age.
Concrete Engineering.
Contractor.
Cornell Civil Engineer.
Daily Consular and Trade Reports.
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Iron Trade Review.
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Mining Science.
Mining World.
Modern Machinery.
Moody's Magazine.
Motor.
Motor Age.
Motor Boat.
Motor Car.
Motor Traffic.
Municipal Engineering.
Municipal Journal and Engineer.
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Popular Science Monthly.
Power.
Power and Transmission.
Power Wagon.
Printers' Ink.
Profitable Advertising.
Progressive Age.—See Adv. opposite.
Railroad Gazette.
Railway Age.—See Adv. opposite.
Railway and Engineering Review.
Railway and Locomotive Engineering.
Railway and Marine World.
Railway Engineering.
Railway Master Mechanic.
Roadmaster and Foreman.—See Adv. opposite.
Rose Technic.
Scientific American.
Scientific American Supplement.
Selling Magazine.
Sibley Journal of Engineering.
Southern Machinery.
Stevens Institute Indicator.

Stone.
Street Railway Journal.
Technical World Magazine.
Technology Quarterly.
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Tradesman.
Waterproofing.
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Engineering. (w.) London.
Engineering Review. (m.) London.
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Gas Engineers' Magazine. (m.) London.
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Iron and Steel Trades Journal. (w.) London.
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Ironmongers' Chronicle. (m.) London.
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Minero Mexicano. (w.) Mexico.
Mois Scientifique. (m.) Paris.
Organ f. d. Fortschritte des Eisenbahnwesens. (m.) Wiesbaden.
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Revue Technique. (b-m.) Paris.
Revista Marittima. (m.) Rome.
Schiffbau. (s-m.) Berlin.
Schweizerische Bauzeitung. (w.) Zurich.
Stahl und Eisen. (w.) Düsseldorf.
Technique Sanitaire. (m.) Paris.
Zeitschrift für Bauwesen. (q.) Berlin.
Zeitschrift f. d. Gesamte Turbinenwesen. (w.) Munich.
Zeitschrift d. Oest. Ing. und Arch. Ver. (w.) Vienna.
Zeitschrift d. Ver Deutscher Ing. (w.) Berlin.
Zeitschrift für Elektrochemie. (w.) Halle a/S.
Zentralblatt d. Bauverwaltung. (s-w.) Berlin.

Index to Articles begins on Second Page Following.

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INDEX TO ARTICLES

ARCHITECTURE.

For Steel and Reinforced Concrete Building Construction, Foundations, Masonry, etc., see "Engineering Construction and Materials" under CIVIL ENGINEERING; for Heating and Ventilation, see subdivision similarly entitled under MECHANICAL ENGINEERING; for Electric Lighting, see "Lighting" under ELECTRICAL ENGINEERING; for Elevators, see "Hoisting and Handling Machinery" under MECHANICAL ENGINEERING; for Plumbing and Sanitation, see "Sewerage" under MUNICIPAL ENGINEERING.

Apartment Houses.

Apartment Houses. Arch & Bldrs Mag—Feb., 08. 31 figs. 1000 w. 40c. Gives plans and half-tone views of 16 modern and representative apartment houses in New York City.

Concrete Architecture.

Where Concrete Stands for Concrete. H. C. Mercer. Cement Age—Jan., 08. 14 figs. 1600 w. 20c. Gives illustrations showing the pleasing results that followed its frank treatment in a Philadelphia clubhouse.

Public School Buildings.

Public School Buildings in the City of New York. C. B. J. Snyder. Am Arch—Jan. 25, 08. 14 figs. 3300 w. Jan. 29. 27 figs. 1600 w. Each 60c.

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New European Aeroplanes and Airships. Sc Am—Jan. 18, 08. 8 figs. 1900 w. 20c.

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Some of the Venturi Tube Peculiarities. Automobile—Feb. 6, 08. 3 figs. 1700 w. 20c. Discusses the working of carbureters of the Venturi tube type with suggestions for their improvement.

The Evolution of the Petrol Carbureter. J. Wright. Cass Mag—Feb., 08. 7 figs. 3000 w. 40c.

Gasoline Meter.

A French Gasoline Meter for Automobile Use. Automobile—Feb. 6, 08. 4 figs. 2000 w. 20c.

Gear Ratios.

Gear Arrangements and Ratios in Motor-Cars. Engg—Jan. 31, 08. 3 figs. 3700 w. 40c.

Gyroscopic Action of Flywheel.

The Gyroscopic Action of an Automobile Fly-wheel. Automobile—Jan. 16, 08. 2 figs. 2400 w. 20c. Discussess its effect when the car is rounding curves.

Igniters.

Methods of Testing Igniting Apparatus—I. F. W. Springer. El Wld. 7 figs. 3000 w. 20c. Gives simple methods of interest to automobile users.

Motor-Bus.

The Halliford Petrol-Electric Motor-Bus. Engg—Jan. 17, 08. 1500 w. 40c. Describes a vehicle with a generator directly coupled to a gasoline engine, which furnishes current to two motors, each driving a rear wheel by means of a worm gear.

Traction Engine.

A Three-Cylinder Compound Tractor. Engr (Lond)—Jan. 24, 08. 3 figs. 1200 w. 40c.

CIVIL ENGINEERING

BRIDGES.

Arch, Walnut Lane.

Progress on the Walnut Lane Bridge, Fairmont Park, Philadelphia. Eng Rec—Feb. 15, 08. 4 figs. 3100 w. 20c.

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Cost of Constructing a Concrete Trestle and Three Concrete Girder Bridges with Abutments. Eng-Contr—Feb. 5, 08. 3 figs. 1600 w. 20c.

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Erection and Waterproofing of Plate-Girder Bridges at Plainfield, N. J. Eng Rec—Feb. 1, 08. 4 figs. 1200 w. 20c.

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Erection Traveler for the Genesee River Viaduct. Eng Rec—Jan. 18, 08. 4 figs. 2000 w. 20c.

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A Plate-Girder Bridge Replacing a Bowstring Truss in Washington, D. C. W. J. Douglas. Eng News—Feb. 13, 08. 5 figs. 1800 w. 20c.

Riveted Lattice Bridges.

Riveted Lattice for Railroad Bridges of Maximum Span; a Plea for a Return to Rational Design. Geo. Huntington Thomson. Eng News—Jan. 23, 08. 13 figs. 4000 w. 20c. A résumé favoring riveted lattice bridges for railroad service, and opposing the use of structures with pin-connected articulations.

Trestles.

Formulas for Estimating the Quantities of Materials in Timber and Pile Trestles, and Hints on Estimating Costs. Eng-Contr—Feb. 12, 08. 1000 w. 20c.

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Quarrying.

Stone: Quarrying and Preparation for Sale. Quarry—Feb., 08. 4 figs. 2400 w. 40c. I.—Modes of Occurrence of Stone in Nature—Practical Bearing of Geological Conditions Upon Quarrying—Distribution of Quarries in the United Kingdom.

Rock Drilling with Water Jet.

The Use of a Water Jet to Increase the Speed of Rock Drilling and a Formula Estimating the Amount of Water Necessary. Eng-Contr—Feb. 5, 08. 1200 w. 20c.

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Preliminary Work on the Los Angeles Aqueduct. Eng Rec—Feb. 8, 08. 7 figs. 5500 w. 20c.

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Planning and Design of Electric Power Stations. Horace Bott. Surveyor—Jan. 24, 08. 1700 w. 40c. From a paper read before the Society of Architects.

The Cost of Building Construction. Ir Age—Feb. 13, 08. 1 fig. 1100 w. 20c. Describes the approximate cost of buildings of varying widths, lengths and heights.

The Stadium of Syracuse University. Eng Rec—Jan. 18, 08. 5 figs. 4500 w. 20c. Describes the recently completed reinforced-concrete stadium for athletic games, which has a normal seating capacity of 20,000 and covers 6 1-3 acres.

The Westport Reinforced-Concrete Power House. Eng Rec—Feb. 1, 08. 11 figs. 3500 w. 20c. Describes a power house in the outskirts of Baltimore having a capacity of 55,000 HP.

Wooden Constructions for Large Exhibition Buildings. W. Treptow. Z V D I—Jan. 18, 08. 5 figs. 1800 w. 60c. Describes a latticed wooden arch construction for supporting roofs of buildings suitable for large exhibitions, etc.

Conduit.

Conduit of Special Design in Ogden, Utah. Eng Rec—Jan. 18, 08. 4 figs. 2000 w. 20c. Describes a reinforced concrete conduit built at one side of the street, close enough to the surface to permit the street curb and gutter to form its top.

Culvert.

Method and Cost of Constructing a Reinforced Concrete Culvert. Eng-Contr—Feb. 12, 08. 1 fig. 500 w. 20c.

Dams.

Reinforced Concrete Diaphragms for Earth Dams. B. M. Hall. Eng News—Feb. 6, 08. 2 figs. 900 w. 20c. Describes use of a vertical core wall or diaphragm of reinforced concrete for preventing leakage through tunnels made by burrowing animals.

The Construction of Earth Dams by Hydraulic Filling. A. Dumas. Génie Civil—Jan. 11, 08. 14 figs. 4500 w. 60c. Describes methods used on dams in Mexico, the Pacific States and Hawaii.

The Croton Falls Reservoir, Croton Water System, New York. Eng Rec—Jan. 18, 08. 5 figs. 2900 w. 20c. Describes the construction of the main and diverting dams, and their appurtenances, the connecting channel, etc.

The Estimated Cost of the Ashokan Reservoir and Data of Actual Cost of Similar Earth Embankments, Together with a Discussion of the Testimony Submitted in the Investigation of the Ashokan Dam Award—I. Eng-Contr—Feb. 12, 08. 3700 w. 20c.

The Estimated Cost of the Main Ashokan Dams. Eng Rec—Feb. 15, 08. 8500 w. 20c. Gives a statement of the methods followed by the engineers of the Board of Water Supply.

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The High Needle Dams on the Big Sandy River, U. S. A. B. F. Thomas. Engg—Jan. 17, 08. 9 figs. 2000 w. 40c. Describes a series of movable dams of the Poirée type, one of which sustains a head of 18 ft.

Foundations.

Reinforced Concrete Foundations Over Excavations on Paved Streets. John McNeal. Proc Am Soc C E—Dec., 07. 1 fig. 500 w. 80c.

Sinking Well and Cylinder Foundations. Edward Stoney. Engg—Jan. 31, 08. 1400 w. 40c. Gives data on work done by dress divers in sinking bridge, well and cylinder foundations in India.

The Cost of Concrete Foundation Work. Conc Eng—Jan., 08. 500 w. 20c. Gives data on recent work in Bridgeport, Conn.

Pile Protection.

Timber Pile Protection in San Diego Bay. Eng Rec—Feb. 15, 08. 1 fig. 800 w. 20c. Describes method of protection used, which consists of a covering of cement mortar placed around the pile after the latter has been driven.

Reinforced Concrete Construction.

A New Type of Forms for Concrete Work. Eng Rec—Jan. 25, 08, 2 figs. 900 w. 20c. Describes a new type of steel centering, each unit or section of which consists of three light-gage steel sheets, two of them parallel to the desired surface and having between them a third specially corrugated sheet, to which they are securely fastened.

Austrian Government Regulations for the Use of Reinforced Concrete. Beton u Eisen—Jan., 08. 12,000 w. $1.00.

British View of Reinforcing Methods. Thomas Potter. Cement Wld—Jan., 08. 10 figs. 2200 w. 20c.

Deflections of Reinforced Concrete Beams Supported at Two Points. E. Turley. Beton u Eisen—Jan., 08. 2 figs. 1000 w. $1.00. Mathematical exposition, with example.

Form Details for Concrete Work. R. H. Haas. Conc Eng—Jan., 08. 4 figs. 400 w. 20c. Gives details of two systems of forms used in and near New York City.

Methods and Costs of Concrete Construction with Separately Molded Members. W. H. Mason. Mun Eng—Feb., 08. 2400 w. 40c. From a paper read before the National Association of Cement Users.

Proposed Building Ordinance Governing Reinforced Concrete. Mun Eng—Feb., 08. 2000 w. 40c. A report to the National Association of Cement Users by the Committee on Fire Protection.

Reinforced Concrete Construction in Butler Brothers' New Building. R. W. Maxton. Conc Eng—Jan., 08. 8 figs. 1700 w. 20c. Describes methods and forms used in a large building in St. Louis.

Reinforced Concrete: Some Formulas and Tables. Ernest McCullough. Cem Era—Jan. 08. 5 figs. 4600 w. 20c. Serial. This instalment describes and illustrates the construction of the forms used in floors, beams and column work.

Reinforced Concrete from the Contractor's Standpoint. H. H. Fox. Eng News—Jan. 30, 08. 3300 w. 20c. Paper read at the annual convention of the National Cement Users' Association, Jan. 20-25, 1908. Gives positive instructions for carrying out work in an economical and efficacious manner.

Self-Sustained Reinforcement of Structural Shapes in a Cement Stock House. Eng News—Feb. 6, 08. 7 figs. 3200 w. 20c. Describes a storage building in Montreal in which the reinforcement is so designed as to make a self-sustaining steel framework before the concrete is placed.

Spirally Reinforced Concrete Construction. S. Sor. Beton u Eisen—Jan., 08. 6 figs. 1800 w. $1.00. Gives methods for calculating the required reinforcement of beams, columns and piles.

Systems of Reinforced Concrete Construction. Emile G. Perrot. Mun Eng—Feb., 08. 1400 w. 40c. From paper read before the National Association of Cement Users.

Test of Visintini Beams. Edw. L. Soule. The Arch & Engr—Jan., 08. 14 figs. 1500 w. 40c. Gives results of tests on three reinforced concrete trusses of the Warren type used in place of solid beams.

The Calculations of a Frame Construction Encased in Reinforced Concrete. C. Abeles. Beton u Eisen—Jan., 08. 6 figs. 2000 w. $1.00.

The Elastic Behavior of Concrete Construction Under Bending Stress. Herr Heintel. Beton u Eisen—Jan., 08. 8 figs. 2000 w. $1.00.

The Influence of Bond on Size of Reinforcement Bars for Concrete. Wm. P. Creager. Eng Rec—Jan. 25, 08. 1300 w. 20c. Gives a rational method of determining the maximum size of bar that can be used in any given span and system of loading, consistent with the adopted working intensity of adhesion or bond stress in the bar.

The Necessity of Continuity in the Steel Reinforcement of Concrete Structures. E. P. Goodrich. Eng Rec—Feb. 8, 08. 3800 w. 20c. Paper read before the National Cement Users' Association.

The Relation Between Bending Moment and Shear in Reinforced Concrete Beams. B. Loeser. Beton u Eisen—Jan., 08. 8 figs. 2000 w. $1.00. Mathematical exposition, with examples.

Retaining Wall.

Flood Protection Along Cherry Creek in Denver, Colo. Eng Rec—Feb. 15, 08. 4 figs. 1400 w. 20c. Describes the reinforced-concrete retaining walls which form the sides of the new channel used.

Structural Steel Design.

Deflection of Beams. E. Meyer. Z V D I—Feb. 1, 08. 13 figs. 5500 w. 60c. Gives methods for calculating the deflection of beams where the material does not act according to Hooke's Law.

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ROYAL ACADEMY OF MUSIC.

The Annual Competition for the Open Scholarships will be held on Jan. 19 and following days. Candidates must be between the ages of 16 and 19 on Jan. 1, 1914. Entries close Jan. 5. Prospectus and forms of entry may be obtained from the Secretary, Royal Academy of Music, York Gate, Marylebone Road, N.W.

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The Annual Competition for Open Scholarships will be held on Jan. 19 and following days. Candidates must be between the ages of 16 and 19 on Jan. 1, 1914. Entries close Jan. 5. Prospectus and forms of entry may be obtained from the Secretary, Royal College of Music, Prince Consort Road, S

Structural Steel Work. Ernest G. Beck. Mech Wld—Jan. 17, 08. 6 figs. 1000 w. 40c. I.—Riveted Work.

The Design of Struts. W. E. Lilly. Engg—Jan. 10, 08. 12 figs. 3400 w. 40c. Considers the problems involved in the design of a strut, and points out in what way the usually-applied formulas fail to give correct values when estimating its strength; also examines the causes of the failure of the Quebec Bridge.

Tower.

A Reinforced Concrete Observation Tower. Eng Rec—Jan. 25, 08. 3 figs. 1000 w. 20c. Describes methods of erecting an 82-ft. tower in the National Military Park at Vicksburg, Miss.

Tunnels.

New Alpine Tunnels. H. Cox. Z V D I—Jan. 11, 08. 5 figs. 400 w. 60c.

Waterproofing.

History of Asphalts. Hugh Boorman. Waterproofing—Jan., 08. 1800 w. 20c.

The Waterproofing of Concrete—II. Myron H. Lewis. Waterproofing—Jan., 08. 1800 w. 20c. Gives a general outline of available methods.

Waterproofing as Applied to Concrete Structures. A. M. Tipper. Waterproofing—Jan., 08. 2200 w. 20c. Paper discussing the advantages of asphalt; read before the Cement Exhibition Co., Dec. 20, 07.

Waterproof Engineering. Edward W. De Knight. Jl Assn of Eng Socs—Dec., 07. 8 figs. 7000 w. 60c. Paper read before the Boston Society of Civil Engineers, Oct. 16, 07.

MATERIALS.

Cement and Concrete.

Blast Furnace Slag and Portland Cement. Dr. H. Passow. Can Cem & Conc Rev—Jan., 08. 7000 w. 20c. Translated from the Proceedings of the International Congress of Applied Chemistry, Berlin. Sets forth the properties of the blast furnace slag cement.

House-Refuse Clinker Concrete as a Building Material. Sc Am—Jan. 25, 08. 3 figs. 2300 w. 20c. Describes the use of the clinker from the destructors of house refuse in concrete for house building purposes.

Proportions of Concrete and Methods of Mixing. L. C. Wason. Eng Rec—Feb. 15, 08. 3000 w. 20c. A paper read at the Buffalo Convention, National Association of Cement Users, Jan., 08.

Some Conclusions from the Application of a Theoretical Analysis. W. A. Aiken. Cement Age—Jan., 08. 3200 w. 20c. Paper read before the Association of American Portland Cement Manufacturers, New York City, Dec. 9-11, 07.

The Manufacture of Commercial Portland Cement. Richard K. Meade. Min Sc—Jan. 23, 08. 3 figs. 3400 w. 20c. Describes methods used in the burning of raw material, the fuel used, the grinding of the clinker, etc.

The Modern Manufacture of Portland Cement—III. Cement Maker—Jan., 08. 2 figs. 1300 w. 20c. Describes briefly the construction of tube mills.

The New Mill of the Union Portland Cement Co. Eng Rec—Feb. 1, 08. 4 figs. 2600 w. 20c. Describes a recently constructed mill of 2500 bbls. daily capacity.

The Transportation Problem in the Portland Cement Plant. C. J. Tomlinson. Eng News—Feb. 13, 08. 2500 w. 20c.

Titrating of the Cement Raw Mixture. A. L. Larson. Can Cem & Conc Rev—Jan., 08. 2900 w. 20c. Describes the principal methods used for the control of the mixture.

Iron and Steel, Corrosion of.

Relative Corrosion of Wrought Iron and Soft Steel Pipes. T. N. Thomas. Htg & Vent Mag—Jan., 08. 8 figs. 3000 w. 20c. Read at the Jan., 08, meeting of the American Society of Heating and Ventilating Engineers.

The Effect of Coal Gas on the Corrosion of Wrought Iron Pipe Buried in the Earth. Am Gas Lt Jl—Feb. 10, 08. 1800 w. 20c.

Timber Preservation.

Creosote for Timber Preserving. Ry Age—Jan. 31, 08. 1900 w. 20c.

Method of Treating Wood that Is Refractory to Treatment and at the Same Time Subject to Decay. Ry Age—Jan. 31, 08. 1800 w. 20c. Paper read before the U. S. Wood Preservers' Assn., Kansas City, Jan. 24, 08.

RIVERS, CANALS, HARBORS.

Canals.

Construction of Lock 3, Erie Barge Canal. Oscar Hasbrouck. Eng Rec—Feb. 8, 08. 4 figs. 1400 w. 20c.

Statement of Col. Geo. W. Goethals, Chairman of the Isthmian Canal Commission, Before the Senate Committee on Interoceanic Canals. Eng News—Jan. 30, 08. 8500 w. 20c. Extract from the testimony of Col. Goethals of the matter of most interest to engineers and contractors.

The Panama Canal; a Brief Statement of Work, Equipment and Finances. Eng News—Feb. 13, 08. 1 fig. 2400 w. 20c.

Dredging.

Dredging Cost on the St. Lawrence River and in Other Parts of Canada. Emile Low. Eng News—Jan. 30, 08. 2400 w. 20c. Gives tables showing dredging accounts during the fiscal year 1905-1906.

Dredging Machinery—III. S. S. Wyer. Ind Mag—Jan., 08. 2 figs. 600 w. 60c. Describes the difficulties met with in the design of dipper dredges.

Docks and Harbors.

Floating Docks. Harry R. Jarvis. Pract Engr—Jan. 17, 08. 8 figs. 3500 w. 40c. Abstract of paper read before the North-East Coast Institution of Engineers and Shipbuilders on Jan. 10, 08. Gives description of various types of floating docks.

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Quay Wall for the New Dry Dock at the Charleston Navy Yard. Eng Rec—Feb. 1, 08. 6 figs. 2800 w. 20c. Describes the massive reinforced construction used.

The Physical Difficulties of Modern Harbor and Dock Extension. H. C. M. Austen. Engg—Jan. 10, 08. Discusses the demands made by the ever-increasing size of steamships in the way of extension of harbors and docks.

Irrigation and Drainage.

Cement in Reclamation of Deserts. Edmund T. Perkins. Cem Wld—Jan., 08. 16 figs. 3800 w. 20c. Describes some of the great irrigation projects in the Western States in which concrete has played a prominent part in construction.

Egyptian Irrigation Pumping Plants. E. F. Huber. Z V D I—Jan. 11, 08. 31 figs. 6500 w. 60c. Describes a number of recent centrifugal pumping plants installed along the Nile.

Irrigation in Egypt. Engr (Lond)—Jan. 10, 08. 2 figs. 1500 w. Jan. 17. 5 figs. 2400 w. Jan. 24. 13 figs. 4000 w. Each 40c.

Lining of Ditches and Reservoirs to Prevent Seepage Losses. B. A. Etcheverry. Ir Age—Feb., 08. 2 figs. 1600 w. 20c. Describes methods of economically lining irrigating ditches and canals in California.

Swamp and Overflowed Land Drainage in the Mississippi Basin. Eng News—Feb. 13, 08. 2500 w. 20c.

The Reclamation of Minnesota's Wet Lands. G. A. Ralph. Eng News—Feb. 13, 08. 1100 w. 20c. Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors at Champaign, Ill., Jan. 15 to 17, 08.

The Relation of Waterways to Drainage Areas. M. L. Enger. Eng Rec—Feb. 1, 08. 1200 w. 20c. Paper read at the annual meeting of the Illinois Society of Engineers and Surveyors.

Shore Protection.

Foreshore Erosion and Reclamation. Prof. Henry Robinson. Surveyor—Jan. 17, 08. 4300 w. 40c. Paper read before the Surveyors' Institution, London, with discussion.

Stream Flow.

A Logarithmic Diagram for the Flow of Water in Open Channels. George A. Damon. Eng News—Feb. 6, 08. 1 fig. 500 w. 20c. Gives a diagram based on the Chézy formulas for facilitating calculations.

Stream Gaging in the Alpine Regions. P. Levy-Salvador. Génie Civil—Jan. 25, 08. 11 figs. 6000 w. 60c.

Wharf.

Storage Wharf. Mines & Min—Feb., 08. 3 figs. 1500 w. 40c. Describes the coal handling apparatus of the Berwind Fuel Co., at Superior, Wis.

ECONOMICS

Appraisal and Depreciation of Properties.

The Appraisal and Depreciation of Waterworks and Similar Properties. W. H. Bryan. Jl Assn Eng Socs—Dec., 07. 2 figs. 19,000 w. 60c. Paper (with discussion) read before the Club, Nov. 6, 07.

Apprentices, Education of.

The Training of Engineering Apprentices—I. Engr (Lond)—Jan. 17, 08. 2 figs. 3400 w. Jan. 31. 1700 w. Each 40c. Describes a new apprenticeship system adopted by an English firm which has done away with the premium pupil system.

Employer's Liability.

The Dire Cost of and the Best Remedy for Carelessness. Indus Wld—Jan. 20, 08. 3500 w. 20c. Discusses the provisions of the Casey Act on employers' liabilities in Pennsylvania.

Filing Data and Records.

A System of Filing Engineering Notes and Records. Eng Rec—Feb. 8, 08. 4 figs. 3200 w. 20c. Describes an elaborate system used by the City Engineer of Salt Lake City, Utah.

Fire Protection.

An English Automatic Fire-Alarm System. Eng News—Feb. 6, 08. 2 figs. 1700 w. 20c. Describes system in which alarm circuit is closed by the increased sag of a long copper span, due to the sudden rise of temperature.

First Aid Instructions.

First Aid to the Injured. Dr. J. W. Hawes. Mines & Min—Feb., 08. 3 figs. 2300 w. 40c. Gives general instructions in regard to treatment of broken limbs, bleeding, fainting, shocks from electric wires, etc.

Foreign Machine Markets.

Foreign Marketing of American Machinery. Sell Mag—Feb., 08. 800 w. 20c. States the methods used by an exporter of machinery.

Pensions and Insurance for Employees.

A Modern System of Pensioning and Insuring Employees. Ir Tr Rev—Jan. 23, 08. 5 figs. 1500 w. 20c. Describes a comprehensive system evolved and put into effect by Deere & Co., Moline, Ill., manufacturers of steel plows.

Purchasing Methods.

A Systematized Purchasing Department. Ir Age—Jan. 23, 08. 7 figs. 2400 w. 20c. Describes the method of handling buying records evolved by the purchasing agent of the Hudson Companies, and gives illustrations of the forms used.

Shop Costs.

A Simple System of Recording Shop Costs. C. J. Redding. Outlines a system that has proved successful in an English works employing three thousand men.

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Methods of Ordering and Routing Work. Oscar E. Perrigo. Ir Tr Rev—Feb. 6, 08. 5 figs. 2700 w. 20c. Fifth of a series of articles on cost keeping and shop management.

Tabulating Machine.

Mechanical Office Appliances. G. W. Oliver. Ry & Eng Rev—Jan. 25, 08. 5 figs. 2600 w. 20c. Describes card punch and effective sorting and tabulating machine for use in railway statistical work.

ELECTRICAL ENGINEERING

ELECTROCHEMISTRY.

Electrochemical Analysis.

Electrochemical Analysis with Rotating Anodes by the Industrial Laboratory. Andrew M. Fairlie and Albert J. Bone. Electrochem & Met Indus—Feb., 08. 3300 w. 40c. II.—Methods of Analysis and Procedure.

Electrolysis.

Electrolysis. Albert F. Ganz. Prog Age—Feb. 1, 08. 8 figs. 10,000 w. 20c. Paper, with discussion, read before the Am. Gas Inst., Washington, Oct. 7, 07.

ELECTROPHYSICS.

Air Gap, Reluctance of.

The Reluctance of the Air Gap in Dynamo Machines. Thos. F. Wall. El Engr—Jan. 10, 08. 5 figs. 2400 w. 40c.

Alternate Current Transmission in Cables.

The Theory of Alternate Current Transmission in Cables (concluded). C. V. Drysdale. Elecn—Jan. 10, 08. 4 figs. 1500 w. 40c.

Electric Discharge in Gases.

The Electric Discharge in Monatomic Gases. Frederick Soddy. Engg—Jan. 31, 08. 2 figs. 8000 w. 40c. Paper read before the Royal Society, Nov. 7, 07.

Magnetic Leakage in Induction Motors.

Magnetic Leakage in Induction Motors. R. E. Hellmund. El Wld—Jan. 25, 08. 5 figs. 3600 w. 20c. Gives a detailed account of the various factors which appreciably influence the end-connection leakage.

Magnetic Oscillations in Alternators.

Magnetic Oscillations in Alternators. G W. Worrall. Elec Engr—Jan. 16, 08. 11 figs. 4000 w. 40c. Paper read at the meeting of the Manchester Local Section of the Institution of Electrical Engineers.

Iron Stampings, Heat Conductivity of.

The Heat Conductivity of Iron Stampings. Thos. M. Barlow. Elec Rev—Feb. 1, 08. 5 figs. 3200 w. 20c. Abstract of a paper read recently before the Institution of Electrical Engineers of Great Britain.

Solenoid Design.

Solenoid in Series with Resistance. Charles R. Underhill. El Wld—Jan. 18, 08. 6 figs. 1900 w. 20c.

GENERATORS, MOTORS, TRANSFORMERS.

Alternators.

A High-Frequency Alternator. Louis Cohen. El Wld—Feb. 15, 08. 1 fig. 2400 w. 20c. Suggests method for designing an alternator for wireless telegraph work.

The Non-Synchronous Generator in Central Station and Other Work. W. L. Waters. Proc A I E E—Feb., 08. 3 figs. 1400 w. 80c. Paper read before the American Institute of Electrical Engineers, Feb. 14, 08.

A.-C. Motor.

A New Alternating-Current Motor. Elec Rev—Feb. 15, 08. 2 figs. 1200 w. 20c. Describes a new alternating-current motor, so designed that its speed may be readily changed.

Converters.

Some Developments in Synchronous Converters. Charles W. Stone. Proc A. I E E—Feb., 08. 6 figs. 4600 w. 80c. Paper read before the American Institute of Electrical Engineers, New York, Feb. 14, 08.

D.-C. Generator Design.

The Best Utilization of the Armature of a Direct-Current Generator. Th. Rosskopf. Elek u Masch—Jan. 5, 08. 8 figs. 5500 w. 40c.

D.-C. Motors.

Direct-Current Motors; Their Action and Control. F. B. Crocker and M. Arendt. El Wld—Feb. 1, 08. 1 fig. 1600 w. 20c. IV.—Shunt Motor Speed Control.

Variable-Speed Commutating-Pole Motors. A. C. Ellis. Elec Wld—Feb. 8, 08. 11 figs. 2800 w. 20c. Discusses the legitimate use of interpoles and their advantages.

Motor Generators.

Motor Generators; Their Use and Operation. Norman G. Meade. Power—Feb. 11, 08. 5 figs. 1900 w. 20c. Gives explanations of their various applications and shows how connections are made.

Standard Performances of Electrical Machinery.

Standard Performances of Electrical Machinery. Dr. R. Goldschmidt. El Eng—Jan. 31, 08. 10 figs. 1600 w. 40c. Paper read before the Institution of Electrical Engineers. Gives data for use in the practical comparison of different classes of machinery and supply systems.

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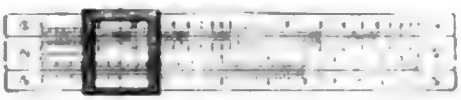

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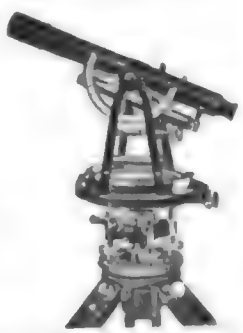

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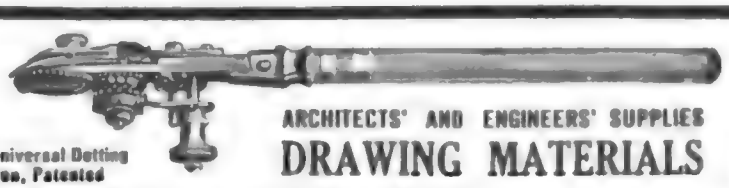

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Transformer Design.

The Design of Small Transformers for Metallic Filament Lamps. F. B. O'Hanlon. El Rev—Jan. 31, 08. 3 figs. 2900 w. 40c.

LIGHTING.

Artistic Interior Illumination.

Artistic Illumination—Murray's Restaurant, New York City. H. Thurston Owens. El Wld—Jan. 1, 08. 14 figs. 1700 w. 20c. Describes what is said to be the most elaborately illuminated restaurant in the world.

Distribution of Illumination.

New Method for Improving the Distribution of Artificial Illumination. W. Voegel. Elek Zeit—Jan. 16, 08. 12 figs. 3000 w. 40c.

Effect of Light on the Eye.

Effect of Light Upon the Eye. Dr. H. H. Seabrook. Prog Age—Feb. 1, 08. 1 fig. 4000 w. 20c. Read before the New York section of the Illuminating Engineering Society, Jan. 9, 08.

Mercury Vapor Lamp.

Kuchs' Quartz Lamp. O. Bussmann. Jl fur Gasbeleuchtung—Jan. 4, 08. 2700 w. 60c. Describes a new high-efficiency mercury vapor lamp, which consists of a quartz tube enclosed in a glass globe.

Photometer.

A New Universal Photometer. Preston S. Millar. El Wld—Jan. 25, 08. 6 figs. 2700 w. 20c. Describes a photometer, by means of which all features necessary to the complete study of a lighting installation can be investigated.

Store Lighting.

Store Lighting. E. L. Elliott. Ill Eng—Jan., 08. 4 figs. 3500 w. 20c. Describes the general conditions to be considered in laying out lighting installations for stores.

PLANTS AND CENTRAL STATIONS.

Auxiliaries.

Steam or Electrically-Driven Auxiliaries? El Rev—Feb. 8, 08. 3 figs. 2800 w. 20c. Discusses this mooted question.

Central Station Practice.

Central Station Practice at New Orleans, La. El Wld—Feb. 15, 08. 4 figs. 4000 w. 20c.

Power House Design.

Notes on the Planning and Design of Buildings for Power Works for the Generation of Electricty. Horace Boon. Jl Soc Archs (Lond)—Feb., 08. 7 figs. 5000 w. 60c.

TELEPHONY.

Automatic Telephony.

Automatic Telephony—III. Franklin J. Truby. W Elecn—Jan. 25, 08. 5 figs. 2300 w. 20c.

Line Construction.

Outside Telephone Construction. C. E. Fleager. W. Elecn—Feb. 15, 08. 1 fig. 3500 w. 20c. A lecture delivered at the College of Engineering, University of Washington, Seattle, Dec. 18, 07.

TESTS AND MEASUREMENTS.

Induction Motors, Test for.

The Hopkinson Test as Applied to Large Induction Motors. N. Pensabene-Perez. Elec Rev (Lond)—Jan. 24, 08. 2 figs. 1800 w. 40c.

Liquid Resistances.

The design of Liquid Resistances. El Engr—Jan. 31, 08. 2 figs. 1200 w. 40c. Gives methods for designing water resistances for use in testing large generators.

Measuring Instruments, Faults in.

Electrical Measuring Instruments and Some of Their Weaknesses. K. Edgcumbe. Elec Engr—Jan. 16, 08. 3400 w. 40c. Paper read before the Association of Engineers-in-Charge.

Self Induction.

Measurement of the Coefficient of Self-Induction of a Circuit Under Normal Load. C. C. Chapin. Elec Wld—Feb. 8, 08. 4 figs. 2300 w. 20c. Describes method consisting essentially of separating the counter e.m.f. of inductance from that of resistance, and measuring it alone.

Watt-Hour Meters.

The Design of Prepayment Watt-Hour Meters. Arthur Pestel. El Wld—Jan. 18, 08. 4 figs. 2300 w. 20c.

TRANSMISSION, DISTRIBUTION, CONTROL.

Concrete Poles.

Recent Experiments in Concrete Pole Construction, with Figures of Cost. Engg-Contr—Jan. 29, 08. 6 figs. 1500 w. 20c.

Inductive Voltage Drop, 3-phase Transmission.

Inductive Voltage Drop on Three-Phase Transmission, with the Conductors Lying in the Same Plane. Alfred Still. El Engr—Jan. 10, 08. 5 figs. 2200 w. 40c. Gives a graphic method for use in calculations.

Insulators for High Voltage.

High tension Insulators from an Engineering and Commercial Standpoint. C. E. Delafield. Can El News—Jan., 08, 3500 w. 20c. Paper read at the annual convention of the Canadian Electrical Association.

High-Voltage Insulator Manufacture. Walter T. Goddard. El Rev—Feb. 8, 08. 16 figs. 4600 w. 20c. Paper read before the Electrical Section of the Canadian Society of Civil Engineers, Dec. 19, 07.

Long Distance D. C. Transmission.

Long-Distance Electric Power Transmission by Direct Current. L. A. Herdt. Elec Rev—Feb. 15, 08. 1800 w. 20c. A paper read before the Canadian Society of Civil Engineers, Nov. 7.

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Overhead Transmission Lines.

Labor Cost of Building a 20-Mile High Power Transmission Line. Engg-Contr—Feb. 5, 08. 1 fig. 2400 w. 20c.

Overhead Construction for High-Tension Electric Traction or Transmission. R. D. Coombs. Dec., 07. Proc Am Soc C E, Dec., 07. 9 figs. 11,000 w. 80c. Gives formulas, tables and constants for the design of conductors, suggested specifications. Paper read Feb. 5, 08, before the Am. Soc. C. E.

Stresses in Overhead Electrical Transmission Lines. A. Kann Zeit Oest Ing U Arch—Jan. 24, 08. 4 figs. 3000 w. 60c. Describes graphical method of calculating the stresses due to weight, ice loading, temperature changes, etc.

Protection of Circuits.

Circuit-Interrupting Devices. F. W. Harris. Elec Jl—Feb., 08. 6 figs. 2700 w. 20c. IV.—Circuit Breakers.

Protective Relays. M. C. Ripinski. Elec Jl—Feb., 08. 6 figs. 1800 w. 20c. II.—Direct-current reverse current relays; instantaneous action.

The protection of Electric Circuits and Apparatus from Lightning and Similar Disturbances. R. P. Jackson. Elec Jl—Feb., 08. 4 figs. 200 w. 20c. Describes general considerations of static disturbances, their causes and effects.

Switchboards.

Electrically Operated Switchboards. S. Q. Hayes. El Wld—Jan. 1, 08. 8 figs. 4300 w. 20c. Deals with panels, desks and pedestals.

MISCELLANEOUS.

Cost of Power.

Cost of Electrical Power for Industrial Purposes. John F. C. Snell. Engg—Jan. 17, 08. 15,000 w. 40c. Paper read before the Institution of Electrical Engineers, Jan. 9, 08. Discusses cost of power in independent plants, giving data for a large number of industries; also the cost of central power plants and the economics of municipal electric power supply plants.

Electrically-Driven Cement Mill.

The Electric Drive in a New Cement Mill. A. Bickel. Eng Rec—Feb. 15, 08. 1 fig. 1500 w. 20c. Describes the construction, equipment and operation of the new plant of the Kansas City Portland Cement Co.

Electrical Progress in 1907.

Electrical Engineering Progress in the United States During 1907. Henry H. Norris. Sibley Jl Engg—Jan., 08. 4 figs. 700 w. 40c.

Electric Manufacturing Plant.

The Felten and Guilleaume-Lahmeyerwerke A. G., Frankfort. Engg—Jan. 24, 08. 6 figs. 3200 w. 40c. Gives details of a large electric manufacturing plant in Germany.

Electric Plant Accounting.

For Small Electric Light and Power Companies. J. H. Stewart. Business Man's Mag—Feb., 08. 1100 w. 20c. Describes a successful accounting system for use by small plants.

Law of Lighting Corporations.

The Law of Electric Light Companies. John E. Brady. El Wld—Feb. 1, 08. 2800 w. 20c.

Magnetic Alloy.

Heusler's Magnetic Alloy. A. D. Ross. Elec Rev—Jan. 25, 08. 3 figs. 1200 w. 20c. From a paper read before the Royal Society of Edinburgh. Describes experiments on a magnetic alloy of copper, manganese and aluminum.

Telephotography.

Electrical Transmission of Photographs. G. Mareschal. L'Electricien—Jan. 19, 08. 3 figs. 2200 w. 40c. Describes a new process of photographic transmission by means of the telestereograph of Edouard Belin.

Telephotography. G. Cerbeland. Génie Civil—Feb. 1, 08. 14 figs. 4500 w. 60c. Describes the Korn and Berjonneau system of transmitting photographic pictures over wires.

INDUSTRIAL TECHNOLOGY

Brick Making.

Irregular Heating in Continuous Kilns. Brit Claywkr—Jan., 08. 1600 w. 40c.

Calcium Carbide.

Test of a Low-Voltage Alternator for Calcium Carbide Furnaces. Elec Rev (Lond)—Jan. 17, 08. 2 figs. 1400 w. 40c. Gives results of tests on a 50-volt 8,600-Amp. generator.

Explosives.

High Explosives. Aug. Klock. Sc Am—Jan. 25, 08. 4400 w. 20c. Gives details of the compositions of modern powders.

Gas Engineering.

A Bulletin of Instructions on the Care and Operation of Recuperative Benches. W. A. Baehr. Am Gas Lt Jl—Feb. 10, 08. 3 figs. 18,000 w. 20c. Paper read before the Am. Gas Inst., Oct. 16, 07.

Air Blast Appliances. W. K. Eavenson, W. H. Allen and S. T. Wilson. Am Gas Lt Jl—Feb. 3, 08. 8 figs. 12,000 w. 20c. Paper read before the Am. Gas Inst., Washington, Oct. 18, 07. Describes appliances with which illuminating gas is used under air pressure.

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A Simple Method of Cleaning Gas Conduits. W. D. Mount. Proc. A. S. M. E.—Feb., 08. 2 figs. 1600 w. 80c. Paper to be read before the A. S. M. E., June, 08.

Gas Lighting in Factory. T. J. Litle, Jr. Am Gas Lt Jl—Jan. 27, 08. 2 figs. 2300 w. 20c. Shows the possibilities of the incandescent gas system and gives comparative costs of gas and electric illumination.

Glass Making.

Questions Arising in the Making of Glass. R. L. Frink. Proc. Engg. Soc. of W. Pa.—Jan., 08. 2 figs. 4000 w. 80c. Paper read Dec. 17, 07. Presents the results of extended investigations for determining why window glass is brittle and hard, and why sometimes it is more so than others, composition being the same.

Hydrogen from Water-Gas.

Methods of Obtaining Pure Hydrogen from Water-gas. Dr. A. Charlottenburg. Jl für Gasbeleuchtung—Jan. 28, 08. 1 fig. 3800 w. 60c.

Lime Kilns.

Modern Lime Kilns; The Plant of the Knickerbocker Lime Co., Mill Lane, Pa. Rex C. Wilson. Eng News—Jan. 30, 08. 5 figs. 1100 w. 20c. Describes an example of a modern lime-producing plant.

Marble Working Machinery.

New Machinery for the Application of Abrasives to Marble Working. J. Royden Peirce. Eng News—Feb. 6, 08. 3 figs. 1500 w. 20c. Describes a turning head coping machine for cutting slabs, a two-wheeled molder and a drum rubber for dressing slabs.

Nitrogen, Fixation of.

The Electrical Fixation of Atmospheric Nitrogen. L'Electricien—Jan. 12, 08. 2100 w. 40c. Abstract of a paper read by M. J. Blondin before the Société Francaise de Physique.

The Manufacture of Calcium Cyanamide. John B. C. Kershaw. Elecn—Jan. 24, 08. 4000 w. 40c.

MARINE ENGINEERING

Boilers, Etc.

Boilers of the Hamburg-American Steamer Kronprinzessin Cecilie. Boiler Mkr—Feb. 08. 1 fig. 1000 w. 20c.

Lloyd's Register Boiler Rules. Boiler Mkr—Feb., 08. 4000 w. 20c. Gives extracts from 1907 rules for determining the working pressures to be allowed in new boilers.

Mechanical Draft in Marine Practice. Int Mar Engg—Feb., 08. 5 figs. 8300 w. 40c.

Some Remarks on the Design, Construction and Working of the Marine Boiler. Richard Hirst. Mar Engr & Naval Arch—Feb. 1, 08. 4000 w. 40c. Read before the Mersey Foremen Boilermakers' and Iron Shipbuilders' Association, Liverpool.

Water-Tube Boilers for Battleships. C. Strebel. Z V D I—Jan. 18, 08. 17 figs. 6000 w. Jan. 25, 22 figs. 6000 w. Each 60c. Give details of marine boilers with small tubes (Yarrow, Thornycroft, etc.).

Displacement and Resistance.

Some Experiments on the Effect of Longitudinal Distribution of Displacement Upon Resistance. Int Mar Eng—Feb., 08. 3 figs. 2000 w. 40c. Prof. Herbert C. Sadler. Read before the Society of Naval Architects and Marine Engineers, New York, Nov. 2, 07.

Estimates.

Marine Engineering Estimates. C. R. Bruce. Mech Wld—Jan. 17, 08. 4100 w. Jan. 24. 2100 w. Each 40c. Paper read before the Glasgow Technical College Scientific Society.

Growth of Speed Since 1800.

The Fastest Ships in the World. Int Mar Engg—Feb., 08. 2 figs. 2100 w. 40c. Gives data showing the growth of speed since 1800.

Heating and Ventilating Ships.

The Heating and Ventilating of Ships. Sydney F. Walker. Int Mar Engg—Feb., 08. 6 figs. 4200. 40c. I.—The system of heating by hot water.

Life Boats, Appliances for Manipulating.

Appliances for Manipulating Life Boats on Sea-going Vessels. Axel Welin. Int Mar Engg—Feb., 08. 8 figs. 2200 w. 40c. Read before the Society of Naval Architects and Marine Engineers.

Refrigeration.

The Transportation of Refrigerated Meat to Panama. Roland Allwork. Int Mar Engg—Feb., 08. 11 figs. 3900 w. 40c. Read before the Society of Naval Architects and Marine Engineers, New York, Nov. 22, 07.

Shipbuilding in 1907.

The World's Shipbuilding. Engg—Jan. 24, 08. 2200 w. 40c. Gives statistics of products for 1907.

Steam Engines and Turbines.

Marine Steam Turbine Installations. Mech Wld—Jan. 17, 08. 3 figs. 1500 w. 40c. (Concluded.)

Proportion of Parts of Triple Expansion Engines. John Green. Engr—Feb. 1, 08. 1700 w. 20c. Gives proportions of parts of engines, propellers, boilers and accessories for vessels up to 300 ft. long; taken from recent practice.

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MECHANICAL ENGINEERING

AIR MACHINERY.

Air-Hammer Drills.

See Mining Engineering.

Blowing Engines.

See "Iron and Steel" under Metallurgy.

Fan Blower Efficiency.

Variation in Fan Blower Efficiency. Walter B. Snow. Met Wkr—Jan. 18, 08. 5 figs. 2500 w. 20c.

Gas Flow in Pipes.

The Flow of Gases in Straight Cylindrical Pipes. Dr. Frische. Z V D I—Jan. 18, 08. 6 figs. 10,000 w. 60c. Gives results of an extended series of experiments to determine the influence of velocity, temperature, pressure and tube diameter on the flow.

Pneumatic Tools.

Pneumatic Tools for Boiler Shops.—IV. Charles Dougherty. Boiler Mkr—Feb., 08. 5 figs. 2800 w. 20c. Discusses their operation and care.

Turbo-Compressors.

High-Pressure Turbo-Compressors. Alfred Gradenwitz. Machy—Feb., 08. 4 figs. 1700 w. 40c. Describes compressors of the Rateau type.

FOUNDING.

Brass Mixtures.

Uses of Cothias Metal for Casting. Emil N. Horne. Foundry—Feb., 08. 3 figs. 1100 w. 20c. Discusses mixtures with this base alloy (2 Cu + 1Sn) as a constituent.

Charging Machine.

Annealing Furnace Charging Machine. Foundry—Feb., 08. 3 figs. 1000 w. 20c. Describes a pneumatic machine designed to replace hand trucks for charging malleable annealing ovens.

Coke Consumption in Cupolas.

Coke Consumption in Cupola Practice. G. Buzek. Stahl u Eisen—Jan. 29, 08. 3900 w. 60c.

Cylinder Molding.

Molding a Large Cylinder Casting. C. R. McGahey. Foundry—Feb., 08. 7 figs. 900 w. 20c. Describes method of a southern jobbing foundry and the large section core used.

Die Castings.

The Method of Producing Die Castings. E. Luther Lake. Am Mach—Feb. 13, 08. 6 figs. 2100 w. 20c. Describes the process of casting, the molds, melting pots, and casting machines, etc., also some of the castings and compositions of the non-ferrous metal used.

Direct Casting from Blast Furnace.

Castings Direct from the Blast Furnace. V. C. Irresberger. Stahl u Eisen—Jan. 15, 08. 4100 w. 60c.

Direct Castings from Blast Furnace. J. J. Porter. Castings—Jan., 08. 1 fig. 2700 w. 20c. Read at a meeting of the Associated Foundry Foremen of Cincinnati, O.

Foundry Costs.

The Efficiency Method of Determining Costs to Eliminate All Wastes from Foundry Operations. Harrington Emerson. Ir Tr Rev—Jan. 30, 08. 4 figs. 2400 w. 20c. From an address delivered before the Pittsburg Foundrymen's Association, Jan. 6, 08.

Machine Molding.

Limitations of the Molding Machine. E. H. Mumford. Foundry—Feb., 08. 3200 w. 20c. Discusses the origin and development of molding machine practice.

Molding with Machinery. Joseph H. Hart. Am Mach—Jan. 16, 08. 1400 w. 20c. Describes the principles involved and the methods employed.

Malleable Castings.

The Production of Malleable Castings—I. Richard Moldenke. Ir Tr Rev—Feb. 13, 08. 2500 w. 20c. The first of a series of articles covering the various phases of the malleable process.

Molding with Sweeps.

Molding with Sweeps. H. J. M'Caslin. Castings—Jan., 08. 6 figs. 1800 w. 20c.

Pulley Molding.

A Method of Molding a Web Pulley. W. W. McCarter. Foundry—Feb., 08. 6 figs. 1700 w. 20c.

Vanadium in Cast Iron.

Vanadium in Cast Iron. Ir Age—Feb. 13, 08. 3500 w. 20c. Gives results of a series of tests to determine to what extent vanadium can be used advantageously in the iron foundry.

HEATING AND VENTILATION.

Fuel Economy.

Fuel Economy. L. J. Wing. Htg & Vent Mag—Jan., 08. 1000 w. 20c. Read at the Jan. (1908) meeting of the American Society of Heating and Ventilating Engineers.

Heat Transmission, Coefficients for.

Austrian Coefficients for the Transmission of Heat Through Building Materials. W. W. Macon. Met Wkr—Feb. 8, 08. 10 figs. 1200 w. 20c. Gives the coefficients in English units.

Hot-Blast Heating.

Present Practice in Fan-Blast Heating. Htg & Vent Mag—Jan., 08. 2 figs. 4500 w. 20c. Gives answers by members to a list of 19 questions, together with a summary of the data collected on hot-blast heating.

House Boilers, Rating of.

Rating House Heating Boilers. Eng Rec —Feb. 15, 08. 2 figs. 1400 w. 20c. Gives methods proposed by Prof. Wm. Kent, and included as a part of the topical discussion on testing and rating house-heating boilers at the recent meeting of the American Society of Heating and Ventilating Engineers.

School Heating and Ventilating Plant.

Mechanical Plant of the Stuyvesant High School, New York City.—II. Eng Rec—Jan. 25, 08. 3 figs. 3700 w. 20c. Describes the steam heating and ventilating equipment.

Ventilating Systems.

Modern Systems for the Ventilation and Tempering of Buildings. Percival R. Moses. Eng Mag—Feb., 08. 22 figs. 4000 w. 40c. A general view of the accepted principles and available types of apparatus.

HOISTING AND HANDLING MACHINERY.

Automatic Car Systems.

Design and Construction of Automatic Car Systems. Chas J Steffens. Eng News—Feb. 13, 08. 6 figs. 3800 w. 20c. Describes system in which an automatic dumping car is used in conjunction with a hoist fitted with either a clam-shell bucket or an ordinary hoisting tub.

Bucket Conveyor Systems.

Conveying Machinery. G. v. Hanffstengel. Z V D I—Jan. 25, 08. 47 figs. 5000 w. 60c. Describes several German link-connected bucket conveyor systems.

Cableway.

Lawsons's Patent Looped-Section Cableway. Stuart Todd. Min Wld—Jan. 18, 08. 4 figs. 800 w. 20c.

Coal and Ash Handling Machinery.

Coal and Ash Handling Machinery for Boiler Houses. Werner Boecklin. Ind Mag —Jan., 08. 4 figs. 2300 w. 40c. Discusses in a general way the limitations of usefulness of the coal handling devices in common use.

Elevators.

Boiler Power for Elevators. Charles L. Hubbard. Power—Jan. 28, 08. 1500 w. 20c. Gives methods of estimating the power required for hydraulic and electric elevation.

The Hydraulic Elevator. William Baxter, Jr. Power—Jan. 21, 08. 8 figs. 800 w. Jan. 28. 8 figs. 1400 w. Feb. 4. 8 figs. 2100 w. Feb. 11, 3 figs. 1300 w. Each 20c. Chapters XV.-XVIII, describing pulling and pushing types of machines, their care and adjustment.

Winding Engine.

3000-Horse-Power Winding-Engine. Engg —Jan. 17, 08. 1200 w. 40c. Describes a pair of winding-engines which, from their size and design of drop-valve reversing-gear, are of special interest.

HYDRAULIC POWER PLANTS.

Centrifugal Pumps.

Notes on Centrifugal Pumps.—V. Mech Wld—Jan. 10, 08. 7 figs. 1400 w. 40c.

Hydroelectric Plants.

High-Tension Energy Transmission in Peru. El Wld—Jan. 1, 08. 8 figs. 2700 w. 20c. Describes hydroelectric plants for supplying current to Lima.

New Turbine Station of the Fall River Electric Light Company. El Wld—Jan. 25, 08. 9 figs. 3200 w. 20c.

The Brusio Hydroelectric Plant and Power Transmission in Lombardy. Schw Bau—Jan. 18, 08. 10 figs. $1.00. Gives details of a new development in Northern Italy.

Orifices, Discharge from Small.

Discharge of Water from Minute Orifices. W. R. Baldwin-Wiseman. Surv—Jan. 10, 08. 2 figs. 1700 w. 40c. Discusses the influence of pipe thickness. Paper read before the Association of Water Engineers.

Penstock, Reinforced Concrete.

Reinforced Concrete Penstock. Howard J. Cole. Ind Mag—Jan., 08. 5 figs. 4500 w. 40c. Describes the construction of a reinforced-concrete penstock at the Shawinigan Falls Power plant.

Speed Regulation.

Speed Regulation of High-Head Water Wheels. H. S. Knowlton. Eng & Min Jl—Feb. 15, 08. 1800 w. 20c. Gives two methods of regulating, together with a formula for predetermining the speed regulation.

Turbine Design.

Design of a 400-Kilowatt Reaction Turbine. Henry F. Schmidt. Engr—Feb. 1, 08. 1800 w. 20c. Gives method of determining the number of stages and blades in each expansion and the principal dimensions.

INTERNAL-COMBUSTION ENGINES.

Cylinder Temperatures.

On the Measurement of Temperatures in the Cylinder of a Gas Engine. H. L. Callendar. Engr—Dec. 10, 08. 8 figs. 5300 w. 40c. Paper read before the Royal Society, Nov. 7, 07.

Diesel Engines.

Tests of a 300-HP. High-Speed Diesel Engine. Ch. Eberle. Z V D I—Feb. 1, 08. 7 figs. 4000 w. 60c. Gives results of tests on an engine running from 250 to 500 r.p.m. and showing a mechanical efficiency of 80%.

Tests of 200-HP. Diesel Engines with Fly-Wheel Dynamos. G. Weber. Schw Bau—Feb. 1, 08. 9 figs. 2000 w. 40c.

Gas Engines.

Largest Gas Engines for Electrical Work. (Continued.) Cecil P. Poole. Power—Jan. 21, 08. 4 figs. 900 w. Jan. 28. 2 figs. 1300 w. Each 20c.

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The Construction and Working of Large Gas Engines. P. R. Allen. Mech Engr—Jan. 25, 08. 14 figs. 2300 w. Feb. 1, 10 figs. 2800 w. Each 40c. Paper read before the Manchester Association of Engineers, Jan. 11, 08.

The Gas Engine.—II. Cecil P. Poole. Power—Jan. 21, 08. 20 figs. 10,000 w. III.—Jan. 28. 4 figs. 4500 w. Each 20c.

Gas Producers.

Gas Producers. Rev de Mec—Dec., 07. 40 figs. 8000 w. $1.80. Illustrated description of a large number of gas producers of various types.

Gas and Oil Engine Diagrams and Fuel Data. Peter Eyermann. Power—Jan. 28, 08. 9 figs. 600 w. Feb. 4. 3 figs. 500 w. Each 20c. II.—Gives diagrams showing how various fuels act in internal-combustion engines, with tables giving information on these fuels. III.—Gives diagrams for Diesel engines.

Oil Fuel.

Technical Aspects of Oil as Fuel—V. and VI. F. E. Junge. Power—Feb. 4, 08. 7 figs. 1300 w. Feb. 11. 4 figs. 900 w. Each 20c. Describes the construction and efficiency of the Daimler, Diesel and Haselwander oil engines using benzol and other low-priced coal-tar oils.

Regulation.

Gas Engine Regulation for Direct-Connected Units. Charles E. Lucke. Proc. A. I. E. E.—Feb., 08. 3 figs. 15,000 w. 80c. A paper read before the Boston Branch of American Institute of Electrical Engineers, Jan. 9, 08.

Thermal Efficiency and Compression.

Third Report to the Gas-Engine Research Committee. Frederic W. Burstall. Engg—Jan. 24, 08. 28 figs. 8000 w. 40c. Gives results of tests to ascertain the relation between thermal efficiency and compression.

MACHINE PARTS.

Ball Bearings.

Manufacture and Tests of Double Ball Bearings. Am Mach—Jan. 23, 08. 16 figs. 2500 w. 20c.

The Use of Ball Bearings on Electric Motors. Elec Rev (Lond) Jan. 10, 08. 13 figs 4200 w. 40c.

Band Brakes.

Notes on Band Brakes. Mech Wld—Jan. 10, 08. 3 figs. 1900 w. 40c. Paper by G. L. Leston, read at a meeting of the National Association of Colliery Managers, gives formulas and constants for use in designing.

Cams.

Friction of Cams. Am Mach—Feb. 6, 08. 4 figs. 1500 w. 20c. Develops an equation showing the relations between the angle which the working face of the cam makes with the direction in which the cam rod works, the coefficient of friction and the weight which is to be lifted by the application of a given turning moment to the cam.

Laying Out Cams for Rapid Motions. F. H. Sibley. Machy—Feb., 08. 8 figs. 1500 w. 40c.

Gear Teeth.

The Safe Working Loads for Gear Teeth. Chas. H. Logue. Am Mach—Jan. 16, 08. 7 figs. 3200 w. 20c. States that resistance to wear is of as much importance as resistance to fracture, and gives formulas to properly design for this factor.

Hoisting Hooks.

A Diagram for Designing Hoisting Hooks. Axel Pedersen. Am Mach—Jan. 30, 08. 4 figs. 2400 w. 20c. Gives Professor Bach's formula for stresses in a curved beam and a diagram plotted therefrom for facilitating calculations.

Pistons.

A Rational Method of Checking Conical Pistons for Stress. Prof. George H. Shepard. Proc. Am. Soc. M. E.—Feb., 08. 2 figs. 2000 w. 80c. Paper to be presented at the A. S. M. E. Detroit Meeting, June, 1908.

Quick Return Motion.

Applying a Quick Return Motion to a Horizontal Milling Machine. W. G. Dunkley. Am Mach—Feb. 13, 08. 2 figs. 700 w. 20c.

Reversing Mechanisms.

Reversing Mechanisms for Machine Tools. Luther D. Burlingame. Am Mach—Feb. 6, 08. 15 figs. 3400 w. Feb. 13. 10 figs. 1800 w. Each 20. Describe methods of controlling reciprocating members on various types of machines by means of shifting belts, clutches and other devices.

Rings, Strength of.

Stresses in Solid Beam Sections and the Strength of Chain Rings.—I. Robert H. Smith. Engr (Lond)—Jan. 24, 08. 1 fig. 4500 w. 40c. First installment of a mathematical analysis of the subjects.

Roller Bearings.

Proportions and Loads of Roller Bearings. Am Mach—Feb. 1, 08. 2 figs. 900 w. Feb. 13. 3 figs. 900 w. Each 20c.

Requisites of Practical Roller Bearings.—II. J. F. Springer. Power—Jan. 28, 08. 16 figs. 1300 w. 20c. Describes the constructive features which insure serviceability; what to avoid; roller cages; peculiarities of tapered rollers, etc.

Screw Thread Systems.

Screw Thread Systems. Erik Oberg. Machy—Feb., 08. 7 figs. 3400 w. 40c. Gives a review of the most important information regarding the more common systems.

MATERIALS.

Car Bearings, Alloys for.

Alloys for Railroad Bearings. G. H. Clamer. Foundry—Feb., 08. 3100 w. 20c.

List of Books on

Cement and Plain and Reinforced

CONCRETE

CEMENT AND CONCRETE. By Louis C. Sabin. Second Edition. 583 pages, 161 tables of tests. Price, $5.00.

TREATISE ON CONCRETE, PLAIN AND REINFORCED. By Frederick W. Taylor and Sanford E. Thompson. 584 pages, 172 illustrations, many tables. Price, $5.00.

REINFORCED CONCRETE. By A. Considère. Translated from the French by Leon S. Moisseiff. Second Edition, 253 pages, 32 illustrations. Price, $2.00.

REINFORCED CONCRETE. By A. W. Buel and C. S. Hill. Second Edition, 500 pages, 340 illustrations. Price, $5.00.

CONCRETE AND REINFORCED CONCRETE CONSTRUCTION. By Homer A. Reid. 906 pages, 715 illustrations. Price, $5.00.

REINFORCED CONCRETE. By Charles F. Marsh and William Dunn. Third Edition, 660 quarto pages, 617 illustrations. Price, $7.00.

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION. By F. E. Turneaure, Dean of the College of Engineering, University of Wisconsin, and E. R. Maurer, Professor of Mechanics, University of Wisconsin. 8vo, viii + 317 pages, 11 plates and 130 figures. Cloth, $3.00.

REINFORCED CONCRETE. By Walter Loring Webb and W. Herbert Gibson. 150 pp., 140 illustrations. Price, $1.00.

HANDBOOK ON REINFORCED CONCRETE. For Architects, Engineers and Contractors. By F. D. Warren. 268 pages, many tables and diagrams. Second Edition, revised. Price, $2.50.

ARCHITECTS' AND ENGINEERS' HANDBOOK OF REINFORCED CONCRETE CONSTRUCTION. By L. J. Mensch. 217 pages, 172 illustrations and many tables. Price, $2.00.

CONCRETE STEEL. A treatise on the theory and practice of reinforced concrete construction. By W. N. Twelvetrees. 230 pages, 73 illustrations. Price, $1.90.

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THEORY OF STEEL-CONCRETE ARCHES AND OF VAULTED STRUCTURES. By William Cain. 215 pages, illustrated. Price, 50 cents.

REINFORCED CONCRETE IN FACTORY CONSTRUCTION. By Sanford E. Thompson. Cloth; 6 x 9 ins.; 250 pp.; 159 illustrations. Price, $0.50.

CONCRETE FACTORIES. By Robert W. Lesley. 152 pages, numerous illustrations. Price, $1.00.

INSTRUCTIONS TO INSPECTORS ON REINFORCED CONCRETE CONSTRUCTION. By George P. Carver. Price, 50 cents.

CEMENTS, MORTARS AND CONCRETES. By Myron S. Falk, Instructor in Civil Engineering in Columbia University. 184 pages, numerous illustrations. Price, $2.50.

EXPERIMENTAL RESEARCHES UPON THE CONSTITUTION OF HYDRAULIC MORTARS. By H. Le Chatelier. Translated by Joseph L. Mack. 128 pages. Price, $2.00.

PORTLAND CEMENT. Composition, Raw Materials, Manufacture, Testing and Analysis. By Richard K. Meade, B. S. 385 pages, 100 illustrations. Price, $3.50.

CEMENTS, LIMES AND PLASTERS. By Edwin C. Eckel. 712 pages, 165 figures, 254 tables. Price, $6.00.

PRACTICAL CEMENT TESTING. By W. Purves Taylor, Engineer in charge Philadelphia Municipal Testing Laboratories. 315 pages, 142 illustrations, 58 tables. Price, $3.00.

HYDRAULIC CEMENT. By Frederick P. Spalding. 298 pages, 51 figures. Price, $2.00.

PORTLAND CEMENT, ITS MANUFACTURE, TESTING AND USE. By David B. Butler. 406 pages, 97 illustrations. Price, $5.25.

CALCAREOUS CEMENTS. By Gilbert R. Redgrave and Chas. Spackman. Second Edition, 254 pages, 63 plates. Price, $4.50.

HANDBOOK FOR CEMENT USERS. By Chas. C. Brown. Third Edition, revised and enlarged. 360 pages. Price, $3.00.

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THE CEMENT INDUSTRY. A description of Portland and natural cement plants in the United States and Europe. 235 pages, 132 illustrations. Price, $3.00.

CONCRETE BLOCK MANUFACTURE. Processes and Machines. By Harmon H. Rice. 166 pages, 45 illustrations. Price, $2.00.

MANUFACTURE OF CONCRETE BLOCKS AND THEIR USE IN BUILDING CONSTRUCTION. By H. H. Rice, Wm. M. Torrance, and others. 122 pages, illustrated. Price, $1.50.

HOLLOW CONCRETE BLOCK BUILDING CONSTRUCTION. By Spencer B. Newberry. 25 pages, illustrated. Price, 50 cents.

ARTIFICIAL STONE, TERRA COTTA, ETC. Edited by John Block. 92 pages, illustrated. Price, 25 cents.

DIRECTORY OF AMERICAN CEMENT INDUSTRIES, 1906. By Charles C. Brown. 636 pages. Price, $5.00.

HANDBOOK OF COST DATA. By Halbert P. Gillette. Flexible leather. 622 pages, illustrated. Price, $4.00.

CONCRETE SYSTEM. By Frank B. Gilbreth. (In preparation.)

CONCRETE-STEEL CONSTRUCTION. By Prof. E. Mörsch. (In preparation.)

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A Magnetic Absorption Dynamometer. C. M. Garland. Am Mach—Jan. 30, 08. 4 figs. 600 w. 20c. Describes apparatus in which power is transformed into heat in an armature revolving in a magnetic field, the heat generated being absorbed by water.

Heat Stresses in Iron and Steel.

Heat Stresses and the Formation of Cracks. Carl Sulzer. Boiler Mkr—Feb., 08. 7 figs. 3700 w. 20c. Discusses the question of the formation of cracks in iron and steel by heat stresses.

Stretching Due to Rolling.

Stretching Due to Rolling. Stahl u Eisen—Jan. 29, 08. 2 figs. 2700 w. 60c. Two communications on the action of a metal plate when passed through rolls.

Testing Machines.

New Machines and Methods for Testing Metals. P. Breuil. Rev. de Mec—Dec., 07. 18 figs. 12,000 w. $1.80. Continued from Oct. Describes various testing machines for determining bending and torsional strengths.

METAL WORKING.

Balancing Rotating Parts.

The Balancing of Rotors for High Speed. Hanz Holzwarth. Power—Feb. 11, 08. 10 figs. 1600 w. 20c. Describes the relationship between the static and dynamic conditions and certain methods by which rotors may be dynamically balanced.

Bushings for Jigs.

Movable Bushings. A. J. Baker. Am Mach—Jan. 16, 08. 5 figs. 500 w. 20c. Gives proportions for removable bushings used in jigs for boring holes.

Gear-Cutting Machinery.

Gear-Cutting Machinery.—II. Ralph E. Flanders. Machy—Feb., 08. 24 figs. 5000 w. 40c. Continues the description of the formed milling cutter type of machine for cutting spur gears, the automatic gear-cutter of orthodox design being considered.

Grinding and Lapping.

Accurate Lapping Operations and Small Tools. Am Mach—Jan. 23, 08. 13 figs. 2200 w. 20c.

Grinding Cone Pulleys. J. H. Hollinger. Am. Mach—Feb. 13, 08. 2 figs. 1200 w. 20c.

High-Speed Steel Working.

Treating High-Speed Steel. E. R. Markham. Am Mach—Jan. 23, 08. 6 figs. 900 w. 20c.

Machining Cylinders and Flywheels.

Finishing Gas Engine Flywheels on the Gisholt Turret Lathe. Machy—Feb., 08. 3 figs. 1400 w. 40c.

Machining Gasoline Engine Cylinders. Am Mach—Jan. 23, 08. 8 figs. 1900 w. 20c.

Microscopic Measurements.

The Microscope in the Manufacturing Plant F. A. Stanley. Am Mach—Jan. 16, 08. 7 figs. 1000 w. 20c. Describes the use of measuring microscopes in the inspection work of a large establishment.

Oil Furnaces.

Fuel Oil for General Shop-Furnace Use. Holden A. Evans. Am Mach—Jan. 30, 08. 15 figs. 5000 w. 20c. Describes the construction and performance of furnaces successfully and economically fired with oil at the Mare Island Navy Yard.

Power Requirements of Machine Tools.

Motor Application to Machine Tools. Can Machy—Feb., 08. 3 figs. 2800 w. 20c. Gives horsepower formulas from data prepared by the Westinghouse Co.

Power Requirements of Railroad Shop Tools. L. R. Pomeroy. Am Mach—Jan. 16, 08. 7 figs. 1800 w. 20c. Reprint from the General Electric Review, giving tables of power required by the various machine tools used in railway shops.

Screw-Machine Tools.

Automatic Screw-Machine Turning Tools. C. L. Goodrich and F. A. Stanley. Am Mach—Feb. 6, 08. 16 figs. 3200 w. 20c. Describes method of making and applying box tools with tangent and radial cutters and hollow mills to the automatic screw machine.

Thread Gages.

Making Thread Gages. A. L. Monrad. Machy—Feb., 08. 10 figs. 3500 w. 40c.

REFRIGERATION.

Ammonia Compressors, Faults in.

Some Faults in Ammonia Compressors. F. A. Rider. Ice & Refrig—Feb. 1, 08. 1600 w. 40c. Discusses errors in testing the operation of ammonia compressors—why the indicator fails, etc.

Ammonia in Refrigeration.

Ammonia in Refrigeration. J. H. Hart. Cass Mag—Feb., 08. 1700 w. 40c. Describes the use and advantages of the substance for refrigerating work.

Cold Storage Plant.

Mechanical Plant of the Worcester Cold Storage & Warehouse Company. Howard S. Knowlton. Eng Rec—Feb. 8, 08. 3 figs. 2300 w. 20c. Describes a modern refrigerating installation operating in Massachusetts.

Heat Losses in Ammonia Compression System.

A Problem in Refrigeration. Arthur J. Wood. Ice & Refrig—Feb. 1, 08. 2 figs. 2400 w. 40c. Discusses the heat losses in an ammonia compression system and the solution of a problem as to their cause.

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Purchasing Refrigerating Machinery.

Comparison of Bids for Ice Making and Refrigerating Machinery. Prof. Chas. E. Lucke. Ice & Refrig—Feb. 1, 08. 4 figs. 3800 w. 40c. Discusses the various factors to be considered by the purchasers of refrigerating machinery, as efficiency, clearance, single-acting and double-acting machines, wet vs. dry compression, etc.

SHOPS AND BUILDINGS.

Drafting Room Methods.

Standard Drawing-Room Methods. M. R. Kavanagh. Machy—Feb., 08. 9 figs. 2000 w. 40c.

Pattern Shops.

An Uncommon Type of Pattern Shop. H. J. Kennedy. Am Mach—Feb. 6, 08. 15 figs. 3400 w. 20c. Describes a building employing a variation of the saw-tooth roof and illustrates a number of devices for pattern shop and drawing room.

Organization of the Pattern Shop. Oscar E. Perrigo. Foundry—Feb., 08. 4 figs. 2600 w. 20c. Describes the disposition of the working force to secure the best results, arrangement of the machinery, etc.

Tool-Room System.

Tool-room Arrangement and System. William H. Taylor. Am Mach—Jan. 23, 08. 9 figs. 2400 w. 20c. Enumerates the points to be considered in laying out, in fitting up with racks and boxes and in general management.

STEAM POWER PLANTS.

Bituminous Coals, Basis for Comparing.

Pure Coal (Ash and Moisture-Free) as a Basis for the Comparison of Bituminous Coals. Bull Am Inst. M. E. 1 fig. 3400 w. $2.00. Paper read at the Toronto meeting, July, 07.

Boilers.

Greenwich Boiler Explosion. Engr (Lond) —Jan. 24, 08. 10 figs. 6500 w. 40c. Gives additional testimony regarding the causes of explosion of a thermal storage drum.

The Steward Tubeless Boiler. Comm Motor—Jan. 9, 08. 4 figs. 1800 w. 40c. Gives interesting data and tests of a new form of rapid steam generator for use in power wagons.

Cooling Towers.

Cooling Towers. Charles L. Hubbard. Elec Rev—Jan. 25, 08. 5 figs. 2600 w. 20c. Describes the various types and the advantages derived from their use.

Entropy Diagrams.

Use of Entropy Diagram in Engine Tests. Prof. Sidney A. Reeve. Power—Jan. 21, 08. 1 fig. 2000 w. Jan. 28. 2 figs. 1600 w. Each 20c. Gives simple directions for constructing an entropy diagram from a steam-engine indicator diagram.

Feed-Water, Purification of.

The Purification of Feed-Water. Charles L. Hubbard. Elec Rev—Jan. 18, 08. 7 figs. 2700 w. 20c. Concluded.

Foundation for Engine.

Method of Underpinning an Engine Foundation. Eng-Contr—Feb. 12, 08. 2 figs. 500 w. 20c.

Governors.

Progress of European Governors. George B. Massey. Cass Mag—Feb., 08. 11 figs. 1300 w. 40c. Enumerates the principal governors now in use on the continent for regulating the speed of gas engines.

Heat Flow Through Cylinder Walls.

The Flow of Heat Through the Walls of a Steam Engine Cylinder. F. Thonet. Rev. de Mec—Dec., 07. 4 figs. 10,000 w. $1.80. Mathematical study of heat flow through jacketed and unjacketed cylinder walls.

Incomplete Combustion, Losses From.

Losses Occasioned by Incomplete Combustion of Gases in Furnaces. A. Sosch. Zeit für Dampfkessel u Masch—Jan. 3, 08. 1800 w. Jan. 10, 4 figs. 1200 w. Each 60c.

Indicator Cards, Faults in.

Effect of Long Pipe Diagrams. Herbert L. Seward. Power—Jan. 28, 08. 5 figs. 300 w. 20c. Shows the inaccuracies in indicator cards which are due to the long pipes used in connection with the three-way cock.

Knocks in Engines.

Causes of Knocks in Steam Engines—I. C. J. Larson. Power—Feb. 11, 08. 5 figs. 2300 w. 20c. Explains their causes and gives interesting explanations with simple, practical directions for preventing them.

Mean Effective Pressure.

Mean Effective Pressure. Fred R. Low. Power—Jan. 21, 08. 2 figs. 1600 w. 20c. Gives table for computing mean effective pressure from the initial pressure with different clearances and ratios of expansion.

Oil Separation.

Separation of Oil from Exhaust and Water of Condensation. Prof. Claudius Lee. Power—Feb. 11, 08. 1 fig. 1300 w. 20c.

Power Plant Costs.

Calculations for Power Plants. Dr. Franz H. Hirschland. Electrochem & Met Indus —Feb., 08. 5500 w. 20c. Gives comparative estimates of constructing and operating costs of 800-KW. power plants running by steam, gas and hydroelectric power, respectively.

Management and Efficiency of the Designing Department, and Its Bearing Upon the First Cost and Economy in Operation of Steam-Electric Power Plants. Frank Koester. Elec Rev—Jan. 18, 08. 2200 w. 20c.

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The Central Power Station at the Plant of Walter Baker & Co., Ltd. Elec Rev—Feb. 15, 08. 2 figs. 3300 w. 20c. Describes a new plant in which reheaters are used with the compound engines driving three-phase alternators (600 volts) for power and lighting.

Mechanical Plant of the Stuyvesant High School, New York.—Part I. Eng Rec—Jan. 18, 08. 3 figs. 4400 w. 20c. Describes the power and lighting equipment.

Shipping Weights of Engines.

Graphic Estimation of Shipping Weights of Steam Engines. C. F. Cukor. Power—Jan. 21, 08. 2 figs. 700 w. 20c.

Smoke.

Smoke Density Determination. Edward J. Kunze. Engr—Feb. 1, 08. 2 figs. 1200 w. 20c. Describes a new instrument for same and the method of recording readings.

Smoke Prevention at Newark, N. J. Eng Rec—Jan. 18, 08. 2 figs. 2700 w. 20c. Gives text of recently adopted city ordinance and description of apparatus for preventing smoke used in one of the city's factories.

Steam Economy.

Steam Engines Economies. Thomas Ball. Sibley Jl of Eng—Jan., 08. 7 figs. 3400 w. 40c. Discusses the question of reducing the steam pressure for light loads as regards economy.

Steam-Pipe Lines, Layout of.

Layout and Installation of Steam-Pipe Lines. Warren H. Miller. Am Mach—Feb. 13, 08. 2400 w. 20c.

Steam Turbines.

Labyrinth Packings. Engg—Jan. 10, 08. 3 figs. 2400 w. 40c. Describes the form of packing used in Parsons' steam turbines, which causes the leakage steam to be wire-drawn at a great number of points.

Steam Turbine Construction.—III. T. Franklin. Mech Wld—Jan. 24, 08. 3 figs. 1400 w. 40c.

The Curtis Steam Turbine In Practice.—I. Fred L. Johnson. Power—Feb. 11, 08. 7 figs. 1400 w. Describes the details of construction of a Curtis turbine and gives simple practical directions for its operation and adjustment.

The Elektra Steam Turbine.—I. H. Meuth. Z V D I—Feb. 1, 08. 12 figs. 4500 w. 60c. Describes a single-stage German turbine having adjustable expansion nozzles.

The Manufacture of Small Steam Turbines. K. G. Smith. Machy—Feb., 08. 7 figs. 1300 w. 40c. Describes the constructive features of the Kerr steam turbine.

The Modern Kerr Steam Turbine Illustrated and Described. Indus Wld—Jan. 20, 08. 8 figs. 3200 w. 20c.

Valve Setting.

Setting the Valves of the Fitchburg Engine. Hubert E. Collins. Power—Jan. 28, 08. 11 figs. 1800 w. 20c. Gives a simple explanation of the valve motion and governor, with clear instructions for setting and adjusting the valves.

WOODWORKING.

Belting Problems.

The Belting of Woodworking Machinery. James F. Hobart. Wood Craft—Feb., 08. 3 figs. 1800 w. 20c. Gives along with other useful information, methods of determining the pull in vertical and horizontal belts.

METALLURGY

COAL AND COKE.

Coke from Small Coal.

A Recent Plant for the Utilization of Small Coal. E. M. Hann. Coll Guard—Jan. 31, 08. 5 figs. 4000 w. 40c. From a paper contributed to the South Wales Institute of Engineers. Describes the methods employed in manufacturing the small coal into coke.

Coke Oven.

The Sheldon Retort Coke Oven and Process. S. B. Sheldon. Ir Age—Jan. 16, 08. 3 figs. 4800 w. 20c. Describes a coke oven having a chamber for precoking, the coal being under compression during the coking operation.

COPPER.

Handling Matte.

Method of Handling Matte at Sleby, California. James C. Bennett. Eng & Min Jl Feb. 1, 08. 5 figs. 800 w. 20c. Describes methods in which the material is tapped into shallow pans of steel carried upon all-iron trucks moved by means of long hook bars.

Leaching and Precipitating.

Leaching and Precipitating Copper. Pierce Barker. Mines & Min—Jan. 24, 08. 5 figs. 2200 w. 20c. Describes methods of extracting the metal from mine waters.

Pyritic Smelting.

Hot Blast in Pyrite Smelting. J. R. Turner. Min Jl—Jan. 25, 08. 800 w. 40c.

The Question of Ore Concentration. H. P. Dickinson. Min Sc—Jan. 16, 08. 1700 w. 20c. Discusses the limitations of water concentration as compared with fire treatment and the progress and field of pyritic smelting.

Smelters.

The Douglas Copper Smelter at Foundation, Mex. Percy E. Barbour. Eng & Min Jl—Feb. 8, 08. 6 figs. 1700 w. 20c. Describes a one-level blast-furnace plant, in which the charges are measured, and raised to the feed floor by bucket elevators.

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Utah's Largest Copper Smelter. Robert B. Brinsmade. Min & Minerals—Feb., 08. 8 figs. 4500 w. 40c. Describes the Garfield plant of the American Smelting and Refining Co., Garfield, Utah.

GOLD.

Cyanidation.

Cyanidation in Nevada. L. M. King. Min & Sc Pr—Jan. 25, 08. 3000 w. 20c. Gives data on tests recently made on certain Goldfield ores and outlines an economical method of treatment.

Filter Press.

The Sweetland Filter Press. Ernest J. Sweetland. Eng & Min Jl—Feb. 15, 08. 3 figs. 900 w. 20c. Describes a filter press embodying several special features designed to render every part accessible, and at the same time to avoid having any moving parts in the working of the machine.

Kalgoorlie Goldfield.

Metallurgy of the Kalgoorlie Goldfield. Gerard W. Williams. Eng & Min Jl—Feb. 15, 08. 1 fig. 1400 w. 20c.

Slime Concentration Practice.

Advances in Slime Concentration Practice. Edwin A. Sperry. Min Sc—Jan. 30, 08. 8 figs. 2400 w. Feb. 6. 2 figs. 3200 w. Each 20c. Describes the various improvements of crushing, regrinding, classification and sizing, dewatering and final treatment.

Air Lift Pumps for Slimes. Engr (Lond)—Jan. 10, 08. 9 figs. 3500 w. 40c. Describes the air lifts used by the East Rand Mines for raising the sands and slimes pulps to the settling tanks.

Tube Mill Grinding Costs.

Cost of Grinding Gold Ore in Tube Mills. Eng-Contr—Jan. 15, 08. 1500 w. 20c.

IRON AND STEEL.

Blowing Machinery.

Centrifugal Blowers for Blast Furnaces. Stahl u Eisen—Jan. 15, 08. 13 figs. 3600 w. 60c.

Experience in the Construction and Operation of Gas-Driven Blowing Engines.—II. H. Baer and H. Bonte. Z V D I—Jan. 11, 08. 18 figs. 4500 w. 60c.

Modern Gas Blowing Engines of Unique Design. Frank C. Perkins. Engr—Feb. 1, 08. 16 figs. 2000 w. 20c.

Electrical Equipment of Rolling Mills.

Electric Equipment for Rolling Mills. Ir Age—Jan. 23, 08. 8 figs. 1400 w. 20c. Describes the various applications of the electric drive in the Bethlehem rail and structural mills.

Rolling Mills and Winding Engines Operated by Thury Motors. Elec Rev (Lond)—Jan. 24, 08. 2 figs. 2200 w. 40c. Describes application of motors furnishing constant current at variable pressure.

The Electric Drive of a Large Rolling Mill. W. A. Dick. Elec Jl—Feb., 08. 13 figs. 3200 w. 20c. Describes the apparatus used in a large rolling mill at the plant of the Illinois Steel Company, South Chicago.

Ferro-Alloys.

Ferro-Alloys and Metals for Use in the Steel Industry. W. Venator. Stahl u Eisen—Jan. 15, 08. 5200 w. Jan. 29. 7000 w. Each 60c.

The Manufacture and Use of Ferro-Alloys.—II. Engr (Lond)—Jan. 31, 08. 2 figs. 1900 w. 40c.

Steel-Making Process.

The Chute Steel-Making Process. Ir Tr Rev—Jan. 23, 08. 1 fig. 2000 w. 20c. Describes a process for accomplishing the same results attained by the duplex process, but in a simpler and much cheaper manner.

Steel Works.

The Friedrich-Alfred Steel Works at Rheinhausen. H. Groeck. Z V D I—Jan. 18, 08. 17 figs. 3000 w. 60c. Gives interior views of various parts of the works, with brief descriptions of the more important portions of the equipment.

The Illinois Steel Company's New Plate Mill. Ir Age—Jan. 16, 08. 11 figs. 5300 w. 20c. Describes the first electrically-driven reversing universal plate mill recently installed at South Chicago, Ill.

The Large Billet Mill Engine at the Donora Steel Works. Ir Tr Rev—Jan. 23, 08. 10 figs. 1400 w. 20c. Describes novel features of a 10,000-HP. horizontal girder frame engine for driving a 30-inch billet mill at the Donora plant of the Carnegie Steel Co.

The New Madeline Furnace of the Inland Steel Company. Indus Wld—Jan. 20, 08. 5 figs. 2800 w. 20c.

Tin Plate Plant.

Tin Plate Making at Follansbee, W. Va. Met Wkr—Feb. 15, 08. 12 figs. 3100 w. 20c. Describes the newest complete tin plate plant in the country.

LEAD.

Electrolytic Treatment.

The Electrolytic Treatment of Galena. Edward F. Kern and Herbert S. Auerbach. Mines & Min—Jan. 24, 08. 6500 w. 20c. From the Columbia School of Mines Quarterly, Nov., 07.

Lead-Zinc Gangue.

Gangue and Associated Minerals of Lead and Zinc. Otto Ruhl. Min Sc—Jan 30, 08. 2200 w. 20c. Describes methods of recovering and utilizing fluorspar, barite, marcasite, pyrite, chalcopyrite, and the important bearing of these minerals on the genesis of ores.

Roasting Lead Ores.

The Metallurgy of Lead. J. W. Richards. Electrochem & Met Indus—Feb., 08. 9000 w. 40c. II.—Roasting of Lead Ores.

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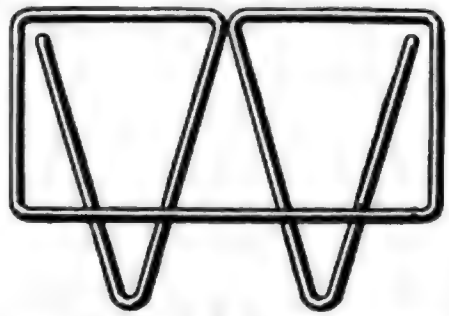

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MISCELLANEOUS.

Melting, Dissolving, Eluting, etc.

Melting, Heating, Dissolving and Eluting. Oskar Nagel. Electrochem & Met Indus—Feb., 08. 6 figs. 2900 w. 40c. Describes methods and apparatus for performing these operations.

Metallurgical Calculations.

The Use of Graphic Formulas in Metallurgical Calculations. David H. Browne. Min & Mining (Denver)—Jan. 17, 08. 6 figs. 3400 w. 20c. A paper presented at the Toronto meeting of the Canadian Mining Institute.

Smelter Smoke.

Smelter Smoke, With a Discussion of Methods for Lessening Its Injurious Effects. L. S. Austin. Min & Sc Press—Nov. 23, 07. 3400 w. 20c.

MINING ENGINEERING

Breathing Apparatus.

Breathing Apparatus for Use in Mines. Prof. Leonard Hill. Engg—Jan. 17, 08. 5800 w. 40c. Lecture delivered at the North Staffordshire Institute of Mining and Mechanical Engineers. Discusses the physiological effect of foul air, and the principles of construction of breathing apparatus.

Breathing Apparatus in Mines. Mines & Min—Feb., 08. 8 figs. 2600 w. 40c. Describes the pneumatogen and aerolith types and results of the English tests of typical apparatus.

Coal.

Coal Dust as a Cause of Mine Explosions. Day Allen Willey. Sc Am—Feb. 1, 08. 2300 w. 20c.

Coal-Mine Explosions. Their Cause and Prevention. Lawrence Brett. Mines & Min—Feb., 08. 3600 w. 40c. Discusses special conditions that exist in the mines of Kansas.

Leasing the Federal Coal Lands. H. Foster Bain. Min & Sc Pr—Jan. 11, 08. 2000 w. 20c.

The Cause of Coal Mine Explosions. William Griffiths. Eng & Min Jl—Feb. 8, 08. 600 w. 20c.

The Middlesboro Coal Field, Kentucky. John Howard. Eng & Min Jl—Jan. 18, 08. 3 figs. 2500 w. 20c. Describes a district possessing a 5-foot seam, which is mined entirely by drifts and slopes.

The Waste of Life in American Coal Mining. Clarence Hall and Walter O. Snelling. Eng Mag—Feb., 08. 5000 w. 40c. Discussion based upon the careful studies and exhaustive data assembled by the explosives expert and the explosive chemists of the U. S. Geological Survey.

Consulting Engineer's Functions.

Functions of the Consulting Mining Engineer. Allen H. Rogers. Eng & Min Jl—Feb. 8, 08. 2200 w. 20c.

Copper.

Analysis of production of Two Great Copper Mines (Calumet & Hecla and Anaconda). Min & Sc Pr—Feb. 1, 08. 1000 w. 20c.

The Evergreen Copper Deposit, Colorado. Etienne A. Ritter. Bull. Am. Inst. M. E.—Jan., 08. 12 figs. 2700 w. $2.00. Paper read at the Toronto meeting, July, 07.

The Cerro de Pasco Mining District, Peru. Clarence C. Sample. Eng & Min Jl—Jan. 18, 08. 5 figs. 2400 w. 20c. Describes an ancient silver camp situated at an altitude of 14,000 ft., now the scene of extensive copper mining and smelting.

The Nevada Copper Fields. A. Selwyn-Brown. Eng Mag—Feb., 08. 14 figs. 3200 w. 40c. A descriptive review of one of the newest and most important copper-bearing regions.

The White Horse Copper Belt in the Yukon.—II. Wm. J. Elmendorf. Min Wld—Feb. 1, 08. 6 figs. 1000 w. 20c.

Drills.

Drills for Stoping. Min & Sc Pr—Feb. 1, 08. 1400 w. 20c.

High vs. Low Pressure for Compressed Air in Mines. Robert B. Brinsmade. Eng & Min Jl—Jan. 18, 08. 1 fig. 1300 w. 20c.

Small Stope Drills. Min Jl—Jan. 18, 08. 2700 w. Jan. 25. 4 figs. 1400 w. Feb. 1. 3 figs. 5000 w. Each 40c. Paper read before the Chemical, Metallurgical & Mining Society of South Africa.

The Air-Hammer Rock Drill and Its Development. T. B. Burnite. Min Wld—Jan. 18, 08. 1100 w. 20c.

The Merits and Demerits of Air-Hammer Drills. G. E. Wolcott. Eng & Min Jl—Feb. 15, 08. 7 figs. 2500 w. 20c.

Explosives for Mining Work.

The Composition and Properties of Mining Explosives. W. H. Graves. Min Sc—Feb. 6, 08. 1400 w. 20c. Describes the characteristics and uses of deflagrating and detonating varieties and gives simple tests for determining the quality of powders and their combustible contents.

Flume Construction.

Notes on Flume Construction. W. C. Ralston. Mines & Min—Feb. 7, 08. 4 figs. 800 w. 20c. Gives cost data for a 4 × 8-ft. flume 2 miles long.

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Geological Survey and the Mining Industry.

The Possibilities and Limitations of Geological Survey Work as Applied to the Mining Industry. Geo. Otis Smith. Min & Sc Pr—Nov. 23, 07. 3900 w. 20c.

Gold.

Development of the Bonanza Creek Gold Mines. Francis C. Nicholas. Min Wld—Jan. 18, 08. 6 figs. 1500 w. 20c.

Methods and Equipment for Prospecting Placers. H. C. Ludlum. Min Wld—Feb. 1, 08. 11 figs. 3000 w. 20c.

Mining Practice at Kalgoorlie, West Australia. Gerard W. Williams. Eng & Min Jl—Jan. 25, 08. 3 figs. 2100 w. 20c. Describes the extraction of the telluride ores by methods insuring perfect ventilation.

The Cripple Creek District of To-day. Hugh T. Van Wagenen. Min & Min (Denver)—Jan. 10, 08. 2 figs. 3000 w.

The Economics of the Deep Level Mines of the Rand. B. J. Collings. Min Jl—Jan. 11, 08. 1100 w. 40c.

The Great Gold Mines.—II. Min & Sc Pr—Feb. 1, 08. 2 figs. 2600 w. 20c.

The Waihi Gold Mines in New Zealand.—II. Ralph Stokes. Min Wld—Jan. 18, 08. 6 figs. 1300 w. 20c.

Graphite.

Canadian Graphite. H. Mortimer Lamb. Eng & Min Jl—Feb. 15, 08. 2100 w. 20c.

Hoisting and Handling Machinery.

A Handling and Dumping System for Mine Cars. O. V. Greene. Min & Minerals—Feb., 08. 5 figs. 2800 w. 40c. Describes a method of combining the car haul and dumping apparatus and saving much expense in tipples.

Chains and Cross-bars for Handling Mine Cars. O. V. Greene. Eng & Min Jl—Feb. 8, 08. 6 figs. 2500 w. 20c. Describes apparatus in which steel bars across the track push the cars over an automatic dumping device to a swift-lift transfer.

Safety Devices for Mine Hoists. U. P. Swinburne and Associates. Eng & Min Jl—Jan. 18, 08. 2 figs. 1800 w. 20c. Concluding portion of the report of the Transvaal Commission. Discusses control of speed in hoisting and the prevention of overwinding, signal systems for engineers, etc.

The Greene Self-Dumping Car Haul. Ir Age—Jan. 30, 08. 9 figs. 2800 w. 20c. Describes a new system of handling and dumping mine cars.

Lead.

The Greenside Lead Mines, Cumberland, England. E. Thomas Borlase. Eng & Min Jl—Feb. 8, 08. 6 figs. 2700 w. 20c.

Velocity of Galena and Quartz Falling in Water. Robert H. Richards. Min & Minerals—Feb., 08. 2 figs. 1600 w. 40c. Describes laboratory experiments and gives mathematical demonstration of a new formula.

Lenticular Plication Veins.

Some Interesting Experiments with Ore-Bearing Veins. Arthur Lakes. Min Sc—Jan. 30, 08. 3 figs. 1400 w. 20c. Describes the occurrence and peculiarities of lenticular plication veins in Idaho, together with their mining.

Mine Surveying.

Mine Surveying. C. E. Morrison. Mines & Min (Denver)—Jan. 10, 08. 5 figs. 3300 w. 20c. From the Columbia School of Mines Quarterly, Nov., 07. Discusses the subject with special reference to shaft surveying.

Mine Values, Calculation of.

Calculation of Mine Values. R. B. Brinsmade. Bull. Am. Inst. M. E. 2200 w. $2.00.

Ore Testing.

Ore Testing at Salt Lake. Ernest Gayford. Min & Sc Pr—Jan. 25, 08. 5 figs. 1200 w. 20c.

Puddling Wet Shafts.

Puddling a Wet Shaft. Henry Boursin. Min & Sc Pr—Jan. 25, 08. 1 fig. 1600 w. 20c. Gives methods successfully used in a British Columbia mine.

Shot-Firing Fuse.

New Fuse for Increasing the Safety of Shot-Firing in Fiery Mines. Coll Guard—Jan. 24, 08. 3 figs. 1500 w. 40c. Describes a safety fuse to prevent miss-fires by igniting the blasting charge along its whole length, and not merely at one point, by means of a leaden detonating tube charged with trinitrotoluene.

Silver.

Genesis of the Lake Valley, N. M., Silver-Deposits. Charles B. Keyes. Bull. Am. Inst. M. E. Jan., 08. 7 figs. 7500 w. $2.00. Paper read at the Toronto meeting, July, 07.

The Montezuma Mining District, Colorado. Etienne A. Ritter. Eng & Min Jl—Feb. 1, 08. 3 figs. 1300 w. 20c. Gives details of a lead-silver-zinc camp on an extension of the Georgetown and Silver Plume Mineral Belt.

Slate Mining.

Slate Mining in Wales and Cause of Its Decline. Eng & Min Jl—Jan. 18, 08. 8 figs. 1400 w. 20c.

Tin.

Notes on Tin. L. A. Humboldt Sexton. Mech Engr—Jan. 3, 08. 3 figs. 4000 w. 40c. Describes the physical and chemical properties of tin, the stanniferous minerals and their distribution.

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Asphalt.

Compressed Rock Asphalt Used on London Roadways. S. A. Ionides. Min Sc—Feb. 6, 08. 3 figs. 1600 w. 20c. Discusses its advantages over the Pitch-Sand Variety of American and European Manufacture together with its preparation and method of laying and preparing.

The Detailed Cost of a Season's Work Laying Asphalt Pavements, Labor and Materials Itemized Separately. F. E. Puffer. Eng-Contr—Feb. 5, 08. 1300 w. 20c.

The Municipal Asphalt Repair Plant of New Orleans—Its Cost and Data on Its Operation. Eng-Contr—Feb. 5, 08. 1 fig. 3100 w. 20c.

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Hysteria in Regard to Pavements. Clifford Richardson. Eng Rec—Feb. 15, 08. 1 fig. 2800 w. 20c. Discusses the tendency of the public to neglect proper consideration of the available evidence in regard to the merits of different forms of pavement.

Pavement Guaranties.

Illegal Guaranties of Pavements. J. W. Howard. Mun Engg—Feb., 08. 2100 w. 40c. A compilation of legal decisions on guaranties of pavements paid by assessments.

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Data on Street Cleaning at St. Louis, Mo. Engg-Contr—Jan. 15, 08. 3000 w. 20c.

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Data on Oiling Park Roadways at Kansas City, Mo. Eng-Contr—Jan. 22, 08. 800 w. 20c. From a report to the Board of Park Commissioners by W. H. Dunn, Superintendent of Parks.

Experiments with Tar and Oil on the Highways of Rhode Island. A. H. Blanchard. Eng Rec—Feb. 8, 08. 1 fig. 3300 w. 20c. Paper read before Section D of the American Association for the Advancement of Science.

SEWERAGE.

Bacterial Counts.

The Significance of Bacterial Counts. Eng Rec—Feb. 1, 08. 1100 w. 20c. From a report by S. De W. Gage, biologist at the Lawrence Experiment Station.

Baltimore Sewerage Works.

A review of the Sewerage Problem of the City of Baltimore. Ezra B. Whitman. Cor Civil Engr—Jan., 08. 1 fig. 5400 w. 20c.

Progress on the Baltimore Sewerage Works. Eng Rec—Feb. 8, 08. 7 figs. 2500 w. 20c.

Boston Sewage Purification.

Purification of Boston Sewage; Experimental Results and Practical Possibilities. C. E. A. Winslow and Earle B. Phelps. Jl of Assn of Engg Socs—Jan., 08. 9500 w. 60c. Read before the Sanitary Section of the Boston Soc. C. E., Nov. 15, 07.

Chicago Drainage Canal.

The Future of the Chicago Drainage Canal. Eng News—Feb. 13, 08. 1 fig. 5000 w. 20c. Editorial discussing the increased work possible should a flow of 14,000 cu. ft. per sec. be permitted.

Ejector for Lifting Sewage.

Pneumatic Ejectors for Lifting Sewage. Surv—Jan. 3, 08. 3 figs. 2000 w. 40c.

Los Angeles Outfall Sewer.

The Completion of the Los Angeles, Cal., Outfall Sewer. Eng Rec—Jan. 25, 08. 5 figs. 4200 w. 20c. Describes the construction of a new 12-mile outfall sewer for conveying the house sewage of the city to the Pacific Ocean.

New Orleans Suit.

The New Orleans Sewerage Case. Alexander Potter. Mun Engg—Feb., 08. 2400 w. 40c. Discusses court decision in a suit arising out of the construction of the sewerage system for the city.

Septic Tanks.

A Reinforced Concrete Septic Tank at Ithaca, N. Y. Eng Rec—Feb. 1, 08. 3 figs. 1400 w. 20c.

Sewerage at Ithaca. Mun Jl & Engr—Feb 5, 08. 3 figs. 2700 w. 20c. Describes and illustrates the reinforced concrete septic tank system used.

The Cameron Septic Tank Patent Sustained by the Court of Appeals. Eng News—Jan. 23, 08. 7500 w. 20c. Extracts from the court decision, with editorial comment.

Sewage Disposal Plants.

Sewage Disposal Plant at the Montefiore Sanitarium. Eng Rec—Feb. 15, 08. 3 figs. 1600 w. 20c.

Sewage Disposal at Worcester, Mass. Mun Jl & Engr—Jan. 22, 08. 4 figs. 2000 w. 20c. Describes the sand filters used in connection with the old chemical precipitation plant.

Sewerage and Sewage Disposal at Fairmont, Minn. A. Marston. Eng Rec—Feb. 1, 08. 5 figs. 1000 w. 20c. Describes system designed for a city of 3,000 inhabitants.

Sludge Disposal.

Notes on Sludge Disposal. Geo. W. Fuller. Eng Rec—Jan. 18, 08. 2600 w. 20c.

Suspended Sewer.

Suspended Sewer. Can Engr—Feb. 7, 08. 8 figs. 1200 w. 20c. Describes a steel pipe sewer suspended from the floor beams of a bridge over a ravine in Toronto.

WATER SUPPLY.

Croton Drainage Area, Capacity of.

How Large a Water Supply Can Be Drawn from Croton Drainage, New York City. Alfred D. Flinn. Eng News—Feb. 6, 08. 3 figs. 3000 w. 20c.

Purification.

Experiences in the Practical Operations of a Mechanical Filter Plant. C. H. Cobb. Eng News—Jan. 30, 08. 1700 w. 20c. Abstract of a paper read before the Illinois Society of Engineers and Surveyors, Champaign, Ill., Jan. 15-16, 08.

Purifying Water for Laundry Purposes. Water—Jan. 15, 08. 1600 w. 40c.

The Cincinnati Water Purification Plant. Eng Rec—Feb. 1, 08. 4 figs. 900 w. 20c.

The Didelon Regulator for Filter-Beds. Engg—Jan. 17, 08. 2 figs. 1100 w. 40c. Describes apparatus for maintaining a constant rate of flow through sand filters.

Reservoir, Portland, Me.

The Water-Works of Portland, Me. W. P. Hardesty. Eng News—Feb. 6, 08. 4 figs. 5000 w. 20c. Describes in detail the reservoir system and gravity pipe line.

Small Water-Works.

The Construction of Small Water-Works. Engg—Jan. 31, 08. 10 figs. 2400 w. 40c. Describes a Scottish example of works so situated that a good gravitation supply can be utilized.

Tuberculation in Pipes.

Tuberculation and the Flow of Water in Pipes. Eng Rec—Jan. 25, 08. 1600 w. 20c. Gives data collected by N. A. Hill, Jr., on the lessening of flow due to deposits in water pipes.

MISCELLANEOUS.

British Municipal Work, 1907-1908.

Municipal Engineering in 1907. Surv—Jan. 31, 08. 35,000 w. 60c. Gives a comprehensive statement of British municipal works projected for the current year, together with a number of specially contributed articles dealing with the work of the past year as regards electrical progress, municipal and public buildings, recent developments in construction, refuse disposal, roads and bridges, sewerage and sewage disposal, street lighting, tramways and water supply.

Civic Centers.

Civic Centers and the Grouping of Public Buildings, with a Suggestion for Boston. Stephen Child. Jl Assn of Engg Socs—Jan., 08. 7 figs. 9000 w. 40c. Read before the Boston Society of Civil Engineers, Nov. 20, 07.

Municipal Engineering in Germany.

Municipal Engineering in Germany. C. E. Wike. Surv—Jan. 10, 08. 5500 w. 40c. A summary of information obtained during the author's visit to the International Congress of Hygiene and Demography, held in September last at Berlin and Hamburg. A report to the Highway and Sewerage Committee of the Sheffield City Council.

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The New Austrian Alpine Railways. Engr (Lond)—Jan. 17, 08. 15 figs. 4400 w. 40c. Describes new Government roads for the improvement of the means of communication with Triest.

British Columbia.

Grade Revision on the Canadian Pacific Railway in British Columbia. Eng News—Jan. 23, 08. 2 figs. 1300. 20c.

Central America.

A Central American Railway. Theodore Paschke. Eng Rec—Jan. 18, 08. 3300 w. 20c. Paper presented by the Costa Rican delegation to the recent Central American Peace Conference. Describes a proposed line and suggests methods of procedure for accomplishing the construction.

Florida East Coast.

Key West Extension of the Florida East Coast Ry. Ry & Eng Rev—Jan. 18, 08. 9 figs. 1500 w. 20c. Gives illustrations showing progress of construction.

Location and Construction.

Railway Location and Construction. H. W. Wagner. Elec Jl—Feb., 08. 5 figs. 1700 w. 20c. Outlines the methods employed in field work.

Ontario.

Construction of the Guelph & Goderich Railway. J. Grant MacGregor. Eng Rec—Jan. 18, 08. 4 figs. 2500 w. 20c.

Philippines.

Railroad Construction in the Philippine Islands. L. F. Goodale. Ry Age—Jan. 31, 08. 10 figs. 3800 w. 20c. Describes the new work recently accomplished and the methods employed.

Portland & Seattle Ry.

The Construction of the Portland & Seattle Railway. W. P. Hardesty. Eng News—Feb. 1, 08. 8 figs. 6500 w. 20c. Describes the construction of a 220-mile line running along the Columbia River and connecting with the N. P. Ry. at Kennewick, Wash., giving a short line to the East from Portland.

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Reconnoissance Into Okanogan Mountains, Washington.—I. Horace F. Evans. Min Wld—Jan. 18, 08. 1600 w. 20c.

MANAGEMENT AND OPERATION.

Operating Time and Grade Reduction.

Operating Time as an Element in Considering Grade Reduction. Eng Rec—Feb. 1, 08. 3 figs. 2000 w. 20c. From a discussion of the report of the Committee on Economics of Railway Location at the last meeting of the American Railway Engineering and Maintenance of Way Association.

Railway Progress, 1895-1905.

A Decade of American Railroad History in Graphic Form. Harold V. Coes. Eng Mag—Feb., 08. 10 figs. 2200 w. 40c. Sets forth in graphic form the various facts showing the growth of American railroads during the period from 1895 to 1905.

POWER AND EQUIPMENT.

Brakes.

Chaumonts' Safety Devices for Automatic Car Brakes. Organ f d Eisenbahn—Jan., 08. 8 figs. 3000 w. $1.00.

Car Construction.

Building Wooden Freight Cars. Am Engr & R R Jl—Feb., 08. 64 figs. 7500 w. 40c. Gives an extended description of the methods employed by the Canadian Pacific Railway, in their Angus shops, Montreal.

The Era of Steel and the Passing of Wood in Car Construction. Arthur M. Waitt. Ry Age—Jan. 24, 08. 2300 w. 20c. From a paper presented at a meeting of the New York Railroad Club., Jan. 17, 08.

Car Wheel Failures.

The Car Wheel and Its Relation to the Rail. S. P. Bush. Ry & Eng Rev—Jan. 25, 08. 9 figs. 10,000 w. 20c. Discusses the failure of car wheels under heavy service and suggests means for prevention.

Freight Houses with Electric Power.

Electrical Power in Railway Goods Warehouses. H. Henderson. El Engr—Jan. 17, 08. 10 figs. 2100 w. Jan. 24, 5 figs. 2200 w. Each 40c. Paper read before the Institution of Electrical Engineers.

Locomotives.

Italian 4-Cylinder Compound Double-Ended Locomotive. Ry Age—4 figs. 2200 w. 20c. Describes a new type of balanced compound locomotive especially adapted for express and freight services upon the steepest grades in mountainous regions.

Layout of the Link Motion of the Heusinger (Walschaert) Valve Gear. L. Baudis. Z V D I—Jan. 25, 08. 7 figs. 1800 w. 60c.

Locomotive Feed-Water Heater. Am Engr & R R Jl—Feb., 08. 5 figs. 1200 w. 40c. Describes a consolidation locomotive on the Central of Georgia Ry., fitted with a heater of the Trevethick type.

New Compound Express Locomotives on the Eastern Railway of France. Ch. Dantin. Génie Civil—Jan. 18, 08. 8 figs. 3000 w. 60c. Describes a new type recently introduced for speed at 70 miles per hour and equipped with Belpaire boilers provided with Serve tubes.

New Locomotives of the North Eastern Railway, England. Chas. S. Lake. Z V D I—Feb. 1, 08. 17 figs. 4500 w. 60c.

Pacific Locomotive for the Lake Shore. Ry Age—Jan. 24, 08. 4 figs. 1600 w. 20c. Describes a heavy type of locomotive provided with a combustion chamber.

Shay Geared Locomotive, Southern Railway. Ry Master Mech—Feb., 08. 2 figs. 700 w. 40c. Describes a locomotive particularly adapted to the heavy grades and sharp curves common to branch coal roads in mountainous districts.

The British Locomotive. A. W. S. Graeme. Mech Engr—Jan. 18, 08. 4200 w. 40c.

The Development of Superheating Apparatus for Locomotives. J. F. Gairns. Cass Mag—Feb., 08. 23 figs. 4800 w. 40c.

Tonnage Rating of Locomotives. B. A. Worthington. Ry & Eng Rev—Jan. 25, 08. 10 figs. 8400 w. 20c. Describes a very complete system of tonnage rating which has been in use for the past nine years on the lines of the Southern Pacific Company. Paper presented at Jan. meeting of the Railway Club of Pittsburg.

Motor Cars.

Gasoline Motor Cars on Small Western Roads. St Ry Jl—Feb. 15, 08. 1200 w. 20c. Gives details of the gasoline cars until traffic has been developed to a point where an electric installation is warranted.

General Electric Gas-Electric Car for Railway Service. Ry Age—Jan. 24, 08. 3 figs. 2600 w. 20c.

Motor Car for the Delaware & Hudson Co. Ry & Eng Rev—Jan. 25, 08. 3 figs. 1900 w. 20c. Describes a new type of gasoline-electric motor car.

Passenger Cars.

Indian Broad-Gage Railways. H. Kelway Bamber. Engg—Jan. 17, 08. 38 figs. 1400 w. 40c. Gives details of the rolling stock used for third-class passenger transportation.

Rails.

The Shape of the American T-Rail Primarily Responsible. A. W. Heinle. Ind Wld—Feb. 10, 08. 2300 w. 20c. Suggests changes in the general shape of the large American T-rail which is not at present in harmony with fundamental principles of rolling and prevents a natural conformation of the metal.

Roundhouse.

The Roundhouse of the Lehigh & Hudson River Railway at Warwick, N. Y. Eng Rec—Feb. 8, 08. 9 figs. 1200 w. 20c. Describes the construction which consists of a flat wooden roof supported on steel and concrete columns and concrete walls.

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Locomotive and Car Shops, Kansas City Southern Railway, Pittsburg, Kan. Ry Eng & M of Way—Jan., 08. 8 figs. 6000 w. 20c.

Structural Features of the Railway Shops at Parsons, Kan. Eng Rec—Jan. 25, 08. 5 figs. 1000 w. 20c.

Signals and Switches.

Automatic Cab-Signaling on Locomotives. I. J. Pigg. Engr (Lond)—Jan. 17, 08. 5 figs. 4000 w. 40c.

New Interlocking Plant, Hoboken Terminal Yard, Delaware, Lackawanna & Western Ry. Eng News—Jan. 30, 08. 9 figs. 5500 w. 20c. Describes a new interlocking plant which exhibits some novel features, tending towards greater safety and dispatch of operation.

New Route-Locking System of Interlocking Signaling, Hoboken Terminal, Lackawanna Railroad. Eng Rec—Feb. 1, 08. 5 figs. 3200 w. 20c.

Transfer Bridges.

The Weehawken Transfer Bridges of the West Shore Railroad. Eng Rec—Feb. 15, 08. 7 figs. 2400 w. 20c. Describes two new double-track timber transfer bridges designed for service in handling the transfer of cars by means of floating equipment.

Weed Killing.

Killing Weeds with Chemical Solution. Ry & Eng Rev—Jan. 18, 08. 800 w. 20c. Describes method using a car for spraying the solution on the roadway.

STREET AND ELECTRIC RAILWAYS.

Car-Testing Plant.

Electric Car-Testing Plant at Worcester Polytechnic Institute. St Ry Jl—Feb. 15, 08. 3 figs. 1900 w. 20c.

Cars.

Long Single-Track Cars Without Monitors. Elec Ry Rev—Feb. 1, 08. 10 figs. 2800 w. 20c.

Typical Traction Cars. Charles A. Heron. Elec Ry Rev—Feb. 1, 08. 8 figs. 1100 w. 20c. Discusses the dimensions, weight and seating capacity of typical cars, based on a compilation made by the author from measurements of nearly 100 cars used by various companies.

Chicago Elevated Loop.

Improvement of the Union Elevated Loop, Chicago. Charles K. Mohler. Ry & Eng Rev—Feb. 8, 08. 1 fig. 2500 w. 20c. Describes a tentative plan for the improvement and extension of the elevated railroad service in the business district of Chicago.

Conduit Construction.

Recent London Conduit Construction. St Ry Jl—Feb. 1, 08. 1100 w. 20c. Describes the latest London practice in conduit electric railway construction.

The Conduit System of Electric Tramway Construction and Recent Improvements. Fitz Roy Roose. El Engr—Jan. 17, 08. 7 figs. 2000 w. 40c. Paper read before the Junior Institution of Engineers.

Electrically Equipped Roads.

Electric Railways in Canada. J. L. Payne. St Ry Jl—Feb. 1, 08. 2500 w. 20c. Analyzes the record of the Canadian companies and points out the possibilities for expansion offered by Niagara power in the East and the rapidly increasing population in the West.

Single-Phase Electric Railways. M. N. Blakemore. Elec Jl—Feb., 08. 1000 w. 20c. Gives data on single-phase roads already built in America.

The Roma Civita Castellana Single-Phase Railway. B. F. Hirschauer. Elec Rev—Feb. 15, 08. 6 figs. 3000 w. 20c.

The Syracuse, Lake Shore & Northern Railroad. E. M. Wharf. St Ry Jl—Feb. 15, 08. 3 figs. 2500 w. 20c.

The Washington, Baltimore & Annapolis Single-Phase Railway. St Ry Jl—Feb. 15, 08. 25 figs. 3700 w. 20c.

Electrification of Railways.

Electrification of Railways.—I. G. Kapp. El Engr—Jan. 31, 08. 10 figs. 5000 w. 40c. Lecture before the Royal Institution, Jan. 18, 08.

Simple Alternating Current Electric Traction on the Railroads of Europe. M. Henry. L'Eléctricien—Jan. 4, 08. 6 figs. 2800 w. Jan. 11, 08. 6 figs. 3200 w. Jan. 19, 08. 4 figs. 2600 w. Each 40c.

Overhead Construction.

A New Suspension for the Contact Wires of Electric Railways Using Sliding Bows. Joseph Mayer. Proc Am Soc C E—Dec., 07. 10 figs. 1200 w. 80c. Paper presented Feb. 5, 08, before the Am. Soc. C. E., New York.

Catenary Construction on the Syracuse, N. Y., Lake Shore and Northern Railroad. El Ry Rev—Feb. 8, 08. 5 figs. 1200 w. 20c.

Railway Converter Design.

Some Features of Railway Converter Design and Operation. J. E. Woodbridge. Proc A I E E—Feb., 08. 9 figs. 1300 w. 80c. Paper read before the American Institute of Electrical Engineers, New York, Feb. 14, 08.

Railway Motors.

A. C. Commutating Motors with Special Reference to Railway Motors. M. Osnos. Elek Zeit—Jan. 9, 08. 6 figs. 3000 w. Jan. 16. 12 figs. 3000 w. Each 40c.

Train Performance.

Electric Train Performance. W. S. Valentine. Elec Jl—Feb., 08. 2 figs. 1600 w. 20c. Describes graphical method for solving problems of train performance, in which the work is materially lessened by the use of a celluloid templet.

THE ENGINEERING DIGEST

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THE CONSTRUCTION OF THE LAGUNA DAM, COLORADO RIVER, ARIZONA

CONDENSED FROM "ENGINEERING NEWS"

The Yuma project of the U. S. Reclamation Service, of which the Laguna Dam is the key, contemplates the irrigation of the valley lands of the Colorado and Gila rivers in the vicinity of Yuma, Ariz. Surveys made during the winter of 1903-4 showed that the area of irrigable land on both sides of the Colorado River was about 90,000 acres.

The Colorado River, aptly termed the "Nile of America," presented more than average difficulties to the engineers of the Reclamation Service in the plans to divert the water from its unstable channel to the adjacent lands. In the course of many centuries the river had built for itself a delta to the Gulf of California, consisting of sand and alluvial mud, whose depth in the Yuma territory the drills failed to establish. The river valley immediately above Yuma is from one to six miles wide. The river channel proper is from 1,000 to 4,000 ft. in width and the slope is approximately 1 ft. per mile. The volume of discharge varies from about 4,000 sec.-ft. at extreme low water to over 100,000 sec.-ft. during flood seasons. At the latter time the stream overflows its banks, submerging the valley lands to a depth of from 1 to 6 ft. This inundation, due to the melting snows at the river sources, occurs annually, and, as a general thing, lasts from May until August.

The stream, along its lower reaches, is continually cutting its banks and changing its channel. Old water courses demonstrate that as the river is to-day so it has been for ages past; its meanderings limited only by the rock bluffs bounding the valley through which it flows. By reason of this cutting of the banks, the stream becomes a very heavy silt bearer after leaving the mountains, and an immense amount of sediment is continually carried in suspension or rolled along its bottom, at times amounting to over 1 part in 50, and averaging through the year .027 by weight.

The size and uncertainty of the river, the shifting channel and unstable banks, the yearly recurring inundations, variations in volume from low water to flood heights and the immense amount of silt carried by its yellow waters, made the problem of the control of the stream unique in the history of American irrigation. The surveys and borings demonstrated that a high dam to serve the lands about Yuma was impossible. Experiments made by private concerns in taking out water from the lower Colorado River, without considering the control of the stream itself, have proved to be extremely hazardous undertakings, menacing not only the enterprise itself by either tearing out headgates or by bar-forming processes, leaving such structures silted up and far inland, but also jeopardizing entire communities, as witnessed by the recent runaway river into the Imperial Valley and the Salton Sink.

With these requirements fully recognized, and with no bedrock for a base, the problem presented to the engineers of the Service was to build a structure founded on the sand and silt of the valley—one that would fully con-

AIR PUMPS AND CONDENSERS*

By R. M. FERGUSON

In the present paper it is not intended to deal with the whole subject of condensation, but rather with the effect upon the vacuum of certain features commonly met with in condensing systems. The term vacuum, as used by engineers, is a variable quantity, dependent upon atmospheric conditions, and all figures should be reduced to a standard barometer of 30 ins. mercury. It is much better to speak of the absolute pressure in a condenser, for it will be independent of any direct atmospheric variation.

The absolute pressure in a condenser is composed of two independent factors—the steam or vapor pressure, and the air pressure. The vapor pressure depends only upon the temperature in the condenser, and this will depend upon the amount of water and steam passing through and the method of transferring the heat from the steam to the water. The air pressure is the main drawback to the securing of a high vacuum in all condensing systems, for it not only adds to the pressure, but also prevents the rapid condensation of the steam. The presence of this air is due to leakage through the glands of the low-pressure cylinder and joints along the exhaust pipe in which the pressure is below that of the atmosphere, and depends on the amount of steam passing through the engine.

The jet condenser is the oldest and simplest form of condenser. The condensing water comes into direct contact with the exhaust steam, and the resulting products are withdrawn by means of an air pump. There are two general types of this condenser, depending on whether the air and water are withdrawn by the same pump—termed a wet-air pump, or whether the air is withdrawn by means of a separate or dry-air pump and the water taken off by a second pump or some other equivalent method.

Jet Condenser with Wet-air Pump.—In this type, which is now often called the parallel-flow condenser, the water enters the condensing chamber in such a manner that it offers a large surface for the steam to condense upon. The steam and water both flow downwards, and the combined products withdrawn at the base along with the air carried into the chamber. The resulting pressure in a perfect condenser of this type may be determined by considering the air and vapor pressure independently, as follows:

If there are n pounds of condensing water per pound of steam entering the condenser at a temperature t_0, and withdrawn along with the condensed steam at the temperature t_1, since the heat given up by each pound of steam in condensing and cooling to t_1 must equal the heat taken up by n pounds of water, we find the hot-well temperature is $t_1 = (1{,}025/n) + t_0$. The constant 1,025 should depend upon the heat contained in the exhaust steam, but for a variation in the temperature of this steam of about 30° F. the amount of heat will only vary about 1%, so that the correction for variations of t_1 will be very small. A factor that may affect this constant to a much larger extent is the unknown quality of the exhaust steam, for part of it may reach the condenser in the form of water.

The hot-well temperature will generally lie between 85° F. and 120° F., and the vapor pressure over this range may be represented as a linear function of the temperature in the form

$$p_1 = 0.0223\ t_1 - 1.29$$

$$p_2 = (22.86/n) + 0.0223\ t_0 - 1.29;$$

thus the vapor pressure depends only upon the amount of condensing water per pound of steam, and upon the initial temperature of this water.

The remaining portion of the condenser pressure is due to the presence of air. The volume of air carried in with the injection water will generally be about 2% of the volume of that water, whilst the air carried over with the exhaust steam will depend upon the volume of steam and the length of the exhaust pipe. Weiss gives this leakage per pound of steam condensed as 1.8 + 0.0035L, where L is the length of the exhaust pipe. This equation has been verified by the author in relation to the air leak into a surface-condensing plant. The total volume of air entering the condensing chamber is taken at atmospheric pressure, so that when it is lowered

*Slightly condensed from a paper recently read before the Manchester Association of Engineers, April, 1908.

to the condenser pressure its volume will be considerably increased and it is this larger volume that has to be dealt with by the air pump. The temperature of this air will be the same as the temperature of the hot-well discharge, and as this will be slightly higher than the initial temperature of the air its volume will be increased slightly, but this increase will in general be small and can be ignored. Making the assumption that the temperature remains constant, we can apply Boyle's law to estimate the resulting pressure when the volume is known. The volume to which the air can expand will be limited by the pump volume and the volume of water discharged. If u represents the bucket displacement in cubic feet per pound of steam, the effective volume of pump = u — volume of water discharged—

effective volume in cu. ft.
$$= u - [(n + 1)/62]$$

The volume of air per pound of steam at atmospheric pressure
$$= (1.8 + 0.003L + 0.02\,n)/62$$
and if p_a be the atmospheric pressure, p_2 the air pressure in the condenser $p_2 = p_a\,(1.8 + 0.003L + 0.02n)/[62u - (n + 1)]$; by adding to this the vapor pressure at the temperature of discharge, we obtain the total condenser pressure, which may be represented by the equation $p = p_a\,(1.8 + 0.003L + 0.02n)/[62u - (n + 1)] + (22.86/n) + 0.0223t_a - 1.29$. (1). This gives a method for estimating the absolute pressure in a condenser in terms of the injection water per pound of steam, the initial temperature of this water and the bucket displacement.

From a study of (1) it will be seen that for any particular bucket displacement there is a limiting value of the vacuum obtainable, depending on the ratio between the amounts of injection water and steam.

An increase of injection water above this value will only decrease the vacuum, for although the larger supply of water will diminish the hot-well temperature and thereby decrease the vapor pressure, this will be overbalanced by the increase in the air pressure due to the larger volume carried in with the water and the relatively smaller bucket capacity.

Thus admitting too large a quantity of water is inefficient in several respects—it entails an additional expense for water, decreases the vacuum obtained, and lowers the temperature of the hot well. This lowering will tend to decrease the efficiency of the plant, when, as is usual, this water has to be used for the boiler feed.

The pump volume as given by the value u represents the minimum value for a perfect pump, and it will generally be found advisable to somewhat increase the actual pump volume to obtain a particular maximum vacuum. With separate air pumps this can be obtained by simply increasing the speed of the pump, but with wet pumps the speed cannot be very high owing to the severe blows produced when the bucket strikes the water, these being liable to produce serious damage to the valves and driving gear.

Other factors which will necessitate a larger pump are, leakage into, and clearance space in the pump itself. This clearance space will generally be filled with a mixture of air and water, and on the return stroke of the bucket the air expands until its pressure has fallen to the condenser pressure. The distance traveled by the bucket during this expansion will represent the lost volume of the pump, and it is only the remainder of the stroke that is effective.

Counter-Current Jet Condensers.—In this type of condenser the exhaust steam enters at the base of the condensing chamber whilst the water enters at the top, and in virtue of its weight will fall through the steam space and offer a large surface for the steam to condense upon. The water is withdrawn at the base, whilst the air carried over with the steam and water is withdrawn at the top by means of a separate dry-air pump. The air carried in with the water does not enter the steam space, whilst the air carried over with the steam is separated in the steam space and gives up part of its heat to the descending water, thus a better vacuum can be maintained in the condenser. The pressure at the lower end will be mainly due to steam, whereas the pressure at the top will be largely due to air; also owing to a smaller amount of air being present in the condensing chamber, the condensation will take place at a greater rate, and thus tend to lower the pressure in the chamber. An additional pump is required to deal with the water alone, either for withdrawing it from the condenser, or enabling it to be drawn in by the vacuum. This latter method is much in vogue at the present time under the form of the Barometric Condenser, in which the condensing chamber is elevated about 30 feet above the discharge pipe. In this case the injection water must be raised by a pump to such a

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height as to enable it to flow into the condenser.

For given amounts of steam and condensing water the total volume of air entering the condenser will be the same as in a parallel-flow condenser, and the total pressure may be estimated in a similar manner. The limiting value of the pressure will be that due to the air at the top of the condenser, and in order to determine the pressure at this point we must know this temperature. It is never possible to reduce the air temperatures quite to that of the injection water. Weiss gives this temperature as

$$t_0 + a \text{ where } a = 7.2 + 0.2\ (t_1 - t_0)$$

t_1 = hot-well temperature, t_0 injection temperature.

By assuming that the whole of the pump is available for the discharge of air, the condenser pressure can be determined as in the case for a wet pump, and is represented by the following expression:

$$p = p_a\ [(1.8 + 0.003\ L + 0.02\ n)/62\ u] + (3.9/n) + 0.019\ t_0 - 0.867 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The vacuum obtainable on the counter-current system is much higher than in a parallel-current condenser using the same quality of water and steam.

The actual volume of air discharged by a dry-air pump will depend more upon the temperature of the air and the clearance volume of the pump than with the wet pump. The volume of air in the clearance space will have to expand down to the condenser pressure before a flow can take place from the condenser to the pump. This lost volume will depend upon the behavior of the air during compression and expansion, but if we assume the temperature to remain constant, the volumetric efficiency = 1 + c—rc, where c is the clearance expressed as a fraction of the working volume, and r the ratio between the atmospheric and condenser pressures. With a clearance volume of 5%, and a condenser pressure of 1½ lbs. per sq. in., the volumetric efficiency is divided into two branches; the steam entering at one of the openings condenses on the outer surface of the larger tubes, whilst the steam entering at the other opening condenses on the inner surface of the smaller tubes; the condensed steam is then withdrawn through branch pipes. The circulating water enters the condenser at a pocket on one end, and has to pass through the annular space between each set of tubes before leaving the condenser. Thus both the inside and outside of the annular water channel are utilized for condensation. By this design a large ratio of L to D is obtained without an undue total length of condenser; the steam and water are also made to flow in opposite directions and act as a contra flow condenser.

Experiments have been carried out on the two surface condensers in the laboratory, and these bear out the points deduced from equation (3). The high-speed condenser contains 61 pairs of tubes, the outer tubes are 1⅛-in. bore and the inner tubes 13/16-in. bore, the average length about 4 ft.; there is only about 1/16-in. clearance between the tubes forming the water space, and the total tube surface is 130 sq. ft.

The main condenser of the ordinary type contains 540 tubes, ⅝-in. diameter, 4 ft. long, divided into two sets, the water first passing through the lower range of 270 tubes and returning along the top range. The tube surface is 353 sq. ft. In all the experiments an equal weight of steam was condensed (about 2,700 lbs. per hour), and the vacuum was varied by changing the quantity of circulating water. The high-speed condenser, although it has only about one-third the tube surface of the main condenser, gives a better vacuum for the same quantity of water and the same capacity of air pump. In both these tests the air pump was worked at a speed of 85 r. p. m., giving a pump volume of 0.77 cu. ft. per pound of steam. To see what effect an increase in the pump capacity would have upon the vacuum, a second series of tests were carried out on the high-speed condenser with the pump speed increased to 96 r. p. m., giving a volume of 0.87 cu. ft. per pound of steam.

The main drawback to condensers of the high-speed type is the larger power required to circulate the water through the tubes of the condenser.

THE MODERN CONSTRUCTION OF MACADAMIZED ROADS*

By THOMAS AITKEN

The subject of this paper—namely, the construction of macadamized roads suitable for modern traffic—has been engaging the attention of road engineers and others interested, for some considerable time past.

That an improvement in the condition of our highways, excellent as they are in many instances, and eminently suitable for slow-going traffic, is necessary no one can gainsay. In order to withstand the increasing number of heavy and fast traveling vehicles some radical change must be made in some of the details of present-day practice in road construction.

Road engineers are occasionally considered by some as not keeping up with the times, and that the art of road making has been lost, but while not agreeing with these statements, there are notable examples in this country of badly made and badly maintained roads which are absolutely unfit to bear the traffic passing over them. Many of these roads will, sooner or later, have to be reconstructed from the foundation.

The revolution in the nature and amount of the traffic has a great deal to do with the complaints made at the present time. It is difficult to foresee what the effect of any new description of road vehicle will be, but now that these conditions, so far as heavy and fast traveling motor cars are concerned, are thoroughly understood; efforts are being made to cope with the difficulty which, while being efficient, may be comparatively economical.

It may be said that the era of bituminous treatment of macadamized roads has been entered upon, and that the methods of construction will give excellent results in regard to wearing capacity, and at the same time get rid of the dust and mud nuisance.

Previous to describing what may be considered the best method of making and maintaining macadam roads suitable for present day requirements, it may be well to consider some of the items which are factors in construction and maintenance generally.

*Paper read before the Glasgow Association of Students of the Institution of Civil Engineers.

FOUNDATIONS.

For all classes of roadway a well-drained, good foundation is a recognized necessity, and on which depends in a great measure the future life of a road and the cost of maintenance. The two great pioneers in road making—Telford and Macadam—differed in their method of forming a foundation. The hand-set bottoming was employed by Telford, and generally bears his name in specifications when new roads are undertaken. It must be remembered, however, that Telford only applied this form of foundation when he could procure suitable material for the purpose, and in many instances used gravel and other kinds of material obtained locally. Many hundreds of miles of new roads were bottomed with gravel in this country by Telford, especially in the Highlands of Scotland.

Macadam did not use a hand-set pavement as a foundation, but preferred to make the roadstones forming the roadway of an equal size. In this respect—and it must be borne in mind that it was principally existing roads he was called upon to improve—Macadam generally found sufficient material in the roads, but of a very irregular size. He, as a rule, picked up the whole roadway, re-formed the ground, drained the subsoil where necessary, and then applied the old material after being freed of superfluous earth, and broken to a uniform size of about 2-in. cubes. He, however, generally stipulated that the weight of each stone was not to exceed 6 oz.

The writer has in practice adopted a system which may be described as a compromise between the methods set out, many miles of new roads having been constructed by this method with excellent results. The rough material, after being placed on the formation level of the road, is broken into cubes of from 3 ins. to 4 ins. in diameter to the requisite depth, generally 9 ins. at the center, and 7 ins. at the sides. This coating is then consolidated by steam rolling, and a 2-in. layer of sand spread over the surface partly to fill the interstices and partly to form a cushion for the top metal,

or wearing surface. The quality of the stones forming the foundation of a road should be of a good and hard description, and not liable to be affected by frost or heavy-wheel traffic. Unfortunately many new roads have been bottomed with soft freestone and with hard core, which, in many cases, means all kinds of rubbish.

It may be of interest to note that some of the roads in certain counties of this country have only a combined depth of material of from 4 ins. to 6 ins., and no doubt this is typical of hundreds of miles of roads in the British Isles. This, no doubt, had been in a great measure brought about on the advent of railways, which drained the roads of their traffic, and consequently the drawings by the turnpike system were considerably reduced. The funds of the road trustees were, therefore, such that proper repairs could not be carried out and the roads suffered in consequence.

It was a common experience during the latter days of the turnpike system, and even up to within a comparatively few years ago, to find the bottoming exposed, and such as it was serving the double purpose of foundation and wearing surface. Since the abolition of the tolls a gradual improvement has taken place, but not to the extent or in proportion to the great advance made in automobilism and of the increased traffic generally.

ROADSTONES.

The selection of suitable road metal for repairing roads is of the utmost importance. The essential qualities are hardness, toughness, durability, and the stones should retain a rough surface under traffic. Materials, the constituent minerals of which are liable to decompose, or are not chemically stable, should be avoided, as the oxidizing influence of air and the solvent action of impure surface water charged with salts and organic acids are destructive elements in road maintenance. Hardness and toughness are seldom equally pronounced in roadstones, although there are notable exceptions, such as in basalt and olivine dolerites, the constituent minerals of which are fresh. Good roadstones depend also on the manner in which the mutual arrangement of the component minerals are disposed and the strength of the base or matrix by which these particles are held together.

For the most part road metal prepared from rocks of the basalt, dolerite and andesite family are generally good, although many dolerites are decidedly unsuitable for road purposes. It appears strange that granite, which is so valuable a stone for engineering structures, should be, with a few exceptions, very inferior as roadstones, compared with those already mentioned. This is particularly so in granite, the quartz crystals of which are coarse in structure.

It is generally admitted that it is more economical, where heavy traffic is experienced, to employ the best material procurable for road repairs, even though it has to be brought from a distance and costs more than a local stone of inferior quality.

Many descriptions of materials have been used for road repairs, such as gravel, flints, limestone, ironstone slag, millstone grit, etc., especially in England, but these for the most part are there being superseded and granite of a good quality and basalt, etc., are being substituted.

BINDING.

A difference of opinion as to the necessity of using a binding material to assist in consolidating roadstone coatings exists, principally by those who study the road problem closely, but who have not the opportunity of gaining practical experience in such matters.

Telford used small gravel to assist in binding the metaling of new roads, whereas Macadam prohibited the use of any extraneous matter for the purpose, contending that the stones should unite by their own angles. It must be remembered that Macadam, as already stated, was principally engaged in reforming and repairing old roads, and that the greater proportion of the material employed had already done service as metaling. The irregular and large-sized stones were broken to a uniform gage of about 2 ins. in diameter, and, of course, a certain amount of earthy matter would still adhere to the metaling, which, without the addition of any other material, formed at once a sufficient binding to ensure cohesion. The old system of carrying out repairs—namely, by spreading the road metal one stone thick in strips or sheets of from 2 ft. to 6 ft. wide in varying lengths, of which method Macadam had a considerable experience—did not require the application of binding. Few road engineers or surveyors practiced binding these patches except under exceptional circumstances. The old road bed was generally sufficiently soft when the metaling was applied, and the stones became set by the passage of vehicular traffic. During the long process of consolidation of these metal patches by the traffic varying conditions of weather were experienced, frost prevailing for weeks, and sometimes for months, at a time. Under these circumstances

what occurred was this: the heavy-wheel traffic forced on to the metal patches, and the old surface of the road being hard, the passage of the vehicles created a grinding action on the stones and considerable abrasion took place. This process not only rounded the edges of the roadstones, but provided indirectly sufficient binding material from the parent roadstones. No doubt this served the purpose of binding the road coatings together admirably, but at the expense of the roadstones; besides the interlocking of the metaling by reason of the edges of the stones being rounded was deficient. Great trouble was also experienced during subsequent dry weather, as the stones became loose and got scattered over the entire road surface.

This method of repairs was practically the only one pursued till the advent of road rollers, but the old-fashioned practice is still carried out to a certain extent at the present time.

The modern system of repairing roads is a great advance on past methods, and serves the purpose well where the class of traffic is slow and moderate in amount.

Continuous full width coatings of metal, 3 ins. to 4 ins. in depth, are spread on to the roads under repair direct from the stonebreakers working in the various quarries. The roadstones, being screened to rid the material of all small and useless stuff, fairly uniform-sized metal is produced. In the consolidation of the coatings by steam rolling a certain amount of suitable material as binding is imperative in order to maintain cohesion between the stones. It is on this, after the metaling has been properly spread, that the success or otherwise of the operation depends. Should large quantities of material of a promiscuous nature be used then bad results may be looked for, and the process is clearly wrong from a sanitary point of view and also from an economical standpoint. This is also the means of creating much dust in dry and mud in wet weather, apart from the actual wear of the stones by wheel traffic. Under such circumstances the stones are never brought into intimate contact, and there is no real solidity, while the volume of mud filling the intersticial spaces is considerable. The effect of this is that during summer weather the mud binding dries, and consequently shrinkage takes place. During winter frost expands the large quantity of moisture in the mud and lifts the road surface. In order to fulfil the best conditions of a good roadway it is necessary to apply binding of a light nature such as loamy-sand, and that in small but sufficient quantities so as to ensure cohesion and a minimum of interstices in the metal coating. Whinstone chippings also make a good binding, and all renewals should be spread with a light covering of these and rolled.

It is the binding, even when the best wear-resisting material is employed as roadstones, which makes or mars a macadamized road, and unquestionably admirable results are obtained when the work is scientifically and practically carried out. Nevertheless, the binding material is the weak spot in road construction. A binding or matrix of a viscous or bituminous nature is now, considering the increasing number of self-propelled vehicles, absolutely necessary if the roads are to be constructed for present-day traffic.

The writer has gone into the matter of binding material rather minutely, but feels that this is the crux of the whole question of efficient road making and maintenance.

ROLLING.

Efficient rolling is a matter of great importance; many roads coated with metaling of good quality suffer and become loose when the water in the binding has dried out. The condition to be aimed at is to solidify the coating with a suitable binding applied in small quantities by rolling so as to approximate the original bulk occupied by the material in the solid. All excess binding should be squeezed out by repeated passages of the roller and swept off. This produces a solid crust capable of resisting most effectually the action of ordinary wheel traffic and containing the least quantity of soluble matter to form mud in wet and dust in dry weather. Steam rollers are made in different weights and used according to the condition of the road to be treated, and the class of material employed for repairs. Consideration also must be given in regard to gas and water mains and other pipes under the roadway, which, in many instances, are quite near the surface, or have but a limited cover. The weight of rollers principally used are 12 and 15 tons; the latter is mostly employed in Scotland, where the roadstones, principally of the igneous type, are generally hard and of good wearing quality. The quantity of metal which can be consolidated in one day by a 15 ton roller varies according to the nature of the stone, class of binding used, efficiency demanded, and the nature and amount of traffic passing over the road where the operations are being carried on. Under favorable conditions

50 to 60 tons of metal can be efficiently consolidated in one day, but this figure may be only 40 tons and even 30 tons where many stoppages are occasioned by traffic and on suburban roads. There are many advocates of dry rolling, principally among those who have but a limited experience in such matters. They consider by continually rolling a coat of metaling that it will become solidified without either binding or the application of water. What really takes place is that the stones become abraded and crushed, and a certain amount of binding material thus obtained, which, on the advent of rain, may bring about a tolerably favorable result. By this system of rolling, however, the roadstones are more or less damaged, and are therefore rendered practically useless before coming into actual use for sustaining the traffic for which the repairs are carried out. This manner of construction brings about much mud in wet and dust in dry weather.

Macadamized roads properly constructed serve the purpose admirably for most kinds of traffic under normal conditions of weather—that is, a macadamized road is at its best when it contains a small percentage of moisture, the binding under these circumstances has a certain amount of cementitious property. It is, however, the abnormal conditions which have to be overcome—namely, the long continued dry weather or a spell of wet weather. In either of the latter conditions considerable abrasion of the individual stones takes place immediately below the surface as the binding loses its cementitious properties, which points to the fact that some medium of a tough nature should be employed as a matrix if macadamized roads are to be improved and made capable of accommodating the new and increasing form of traffic without the accompanying mud and dust nuisance.

TAR-MACADAM.

Unquestionably tar-macadam, or tarring roadstones in some form, will be the future method of constructing highways in this country, especially on main roads. The tar, or tarcompo, as a matrix or binder, in conjunction with a limited quantity of whinstone chippings and dust, effectually binds the roadstones together, and forms a homogeneous and solid mass. This will eliminate internal friction and wear of the metal coatings, a condition of things for the most part inseparable from ordinary macadam. Tar-macadam has been laid as a pavement in many towns—In Nottingham for as long as forty years; but the cost appears to have been prohibitive, and its application could not be undertaken on a large scale.

The system adopted by the county surveyor of Nottingham, which has been in use for some years past, is known as "Tarmac." In this method the material used is furnace slag, which is first heated on plates and boiling tar added, the materials being turned over so as to ensure equal treatment of the slag. The material is then left for some time under cover, in order to drain off the superfluous tar before applying it to the roads. It is claimed that slag absorbs the tar, and therefore when rolled makes a solid and lasting road. It would appear that slag and the various limestones which are capable of absorbing tar, and greatly used in many localities, are not suitable as wear-resisting materials under heavy traffic. In no sense can slag be considered an ideal roadstone. Whinstone and granite may be treated in a similar manner, but the latter in many cases has not proved satisfactory, probably owing to the large quartz crystals in its composition. Tarmac has proved very satisfactory in many cases, while in some instances very variable results have been obtained.

Another method of making tar-macadam has been tried in many localities, but with small success. It consists of pouring boiling tar over the roadstone coating after being partially rolled. The idea is to grout the metaling and then apply chippings to fill the voids at the surface, the rolling being continued to form up the coating. In this method too much tar is unavoidably used, and that in a very irregular manner, while during hot weather the whole coating begins to creep and get out of shape, which ultimately leads to disintegration.

Applying boiling tar to cold roadstones must be considered, as in most instances it will be found that the tar is chilled; under these circumstances it is liable to peel off the stones in wet weather.

Other means of making tar-macadam have been tried by using a flux or binder composed of whinstone or limestone chippings, and thoroughly coating these with hot tar. In repairing a road with coatings of 3 ins. to 4 ins. in depth of metal a layer of this binder is first spread on the old surface previous to applying the metal. Rolling is then proceeded with, the intention being to force the flux up through the interstices of the stones by the action of the roller wheels pressing them downwards. To make this system successful the writer has tried many kinds and proportions of binder of

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this description, but without much success. The matrix to be of any real value must be fairly liquid, and in this condition it cannot be properly handled, while if it is carried out under these conditions it gives great trouble by becoming sticky in hot weather. On the other hand, if it is of a dense composition it will not penetrate the metaling, and may require a top coating of binder, which in turn is forced down through the voids of the metaling. These two applications of binder may meet at the center of the coating, but invariably this does not take place, and only represents a veneer at the lower and top portions of the roadstone coating. On roads with an irregular surface this system is at a disadvantage owing to the metaling having to be spread at varying thicknesses to bring the contour into proper shape.

This method of forming tar-macadam, however, seems to have again been tried recently by others, and is said to give good results. It has appeared on the market as a new process, and is advertised as "Tarvia." This method of road repairing may be seen at Mount Vernon (Glasgow), where a short length of road has been treated by this process.

From the foregoing remarks it is apparent, in order to attain good results in an economical manner, that a form of mechanical apparatus is necessary to treat the roadstones properly after being spread on the road. By such an arrangement the apparatus traverses the metal coating spraying the viscous liquid, under considerable pressure, and forcing it down and under the loose stones, covering them entirely with a film of tar or tar-compo. When this has been accomplished, generally two turns of the machine being necessary, whinstone chippings are applied in limited quantities to fill the interstices of the metal coating. The roadstones are then rolled solid and another application of tar is sprayed over the surface by the machine, chippings and dust are then sprinkled over, and the coating completed by further rolling. By this means the requisite amount of tar necessary for good results is applied, and coatings up to 4 ins. in depth can be treated by this spraying machine. Flooding the roadway with tar is by this means avoided, and each stone receives a proper amount of binder which cannot be attained by hand labor or by machines which depend entirely on gravity for discharging the liquid material.

The amount of chippings necessary to fill the voids in order to make the coating a homogeneous mass depends on the gage of the roadstone used, the smaller the size the less will be the quantity of chippings required. In this case, as is common with all descriptions of tar-macadam, the nature of the stone is an element to be considered. Materials which break with a rough fracture are to be preferred to stones having a fine texture. The camber of roads thus made can be reduced considerably compared with the practice at present.

The method just described is, in the writer's opinion, the cheapest way of making a tar-macadam road, and it is quite as efficient as any other system. It is, however, absolutely necessary that all the materials should be thoroughly dry and the work carried out in fine weather.

The matrix, if it is of refined tar, must possess sufficient toughness to bind the stones together and form a waterproof surface.

If the process of refining is not carried out properly, so as to rid the tar of ammoniacal liquor and naphtha, then the oxidizing influence of the air will affect it adversely, while if the process is pushed too far the tar becomes brittle after setting, and is then easily pulverized by the wheels of vehicles.

The difficulty is in getting the proper grade of tar for this class of work, and in this respect it would appear necessary for the chemist to step in and assist road engineers in arriving at a standard of excellence.

Many compositions are on the market, and considered superior to ordinary refined coal-tar for road purposes. The best preparation of this nature which has come under the writer's observation up to the present time is composed of coal-tar and natural bitumen, in certain defined proportions, and is known by the name of "Marbit." The best of the ordinary materials so far tried is the crude natural bituminous oil from Mexico. These materials set hard and appear to be ideal compositions for forming a matrix or binder for tar-macadam.

PREVENTION OF DUST.

This problem, which is occupying the attention of road engineers and the public generally, can only be satisfactorily solved by constructing the roads with some form of tar-macadam. Nevertheless, as years must elapse before at least all the main roads in this country can be so treated, some method by which the dust nuisance can be eliminated or suppressed will have to be undertaken.

The increasing number of heavy motor wagons and fast-traveling motor cars—indeed, all descriptions of wheel traffic—has brought the

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dust nuisance very prominently before the public.

Its widespread effects may be recognized in the enormous amount of damage done to property by depreciating the value of houses along many of the roads used by motorists and the injury done to gardens and vegetation generally, articles of furniture and clothing, goods and foodstuffs, etc. The hygienic aspect of the question is also of the utmost importance, and the inconvenience caused to pedestrians using the roads and the danger in which they are at times placed constitute a condition of things which needs to be urgently dealt with.

There are several factors which influence the formation of dust, the most important being the character of the roadstones employed, the binding used, and the class and amount of traffic passing over the roads. The wear of the roads is largely due to metal-tired vehicles, horses' hoofs and the pumping action of the large rubber tires of fast-traveling motors cars; the destructive element is intensified when these tires are shod with steel studs or other "side-slip" devices. Experience shows that a motor car traveling at about twelve miles an hour raises no more dust than a four-in-hand coach, but as the speed increases the dust clouds become denser, and the binding and small stones are withdrawn from the metal coating after a long continuance of dry weather.

The internal friction or rubbing together of the stones forming the crust creates dust, and this is augmented by the binding losing its cementitious properties during a spell of dry weather. The design of motor cars has something to do with the amount of dust raised, but it primarily must be in the direction of treating the roads that suppression of the dust will have to be tackled. Different methods have been adopted from time to time to combat the evil, such as watering and the application of various palliative compositions, all of which may be dismissed as being altogether of a temporary nature and withal costly, although some good has resulted from their use. What is really required is a material having a good body or of a viscous nature, such as tar and tar compounds.

In a paper read before the British Association at Southport some years ago the writer advocated spraying tar for the prevention of dust, but the matter did not apparently appeal to the members of the engineering sections at that time.

It is now generally recognized that tar in some form is the only satisfactory material, up to the present time, for the purpose indicated. To adequately treat a road there must be a certain amount of penetration of the liquid, but which may or may not take place, depending on various factors which enter into the question. Brushing tar on a road from buckets, or by hand labor, will not penetrate the surface unless the tar is in a boiling state, but since the stones are cold the liquid is chilled and effective penetration cannot take place. This remark does not apply to the same extent to countries with a warm climate. To effectively penetrate the binding of a road surface pressure is necessary, and the tar should be sprayed on in a highly diffused state. By this means the utmost advantage is obtained of each gallon of tar in relation to a given area of road surface. All tarring operations are contingent on the road surface being thoroughly cleansed of dust and foreign matter, and the lighter the binding material in the road the better will be the application and the greater the penetration. Covering the surface of a road with tar without penetration is not to be recommended, as after a continuance of wet weather the tar peels off and forms slimy mud. Dusting over the surface after tarring is necessary, and this is preferably carried out by using ¼-in. whinstone chippings or similar material. Sand is not so effective and the surface of the road at times becomes polished. For really successful work the road internally and on the surface must be thoroughly dry and the work carried out in fine weather.

There can be no question that when a road is properly treated with tar or a like composition, apart from the suppression of dust, the life of the road is increased and the cost of tarring amply repaid. Tarring roads is the cheapest system for dust prevention, providing the tar is distilled and of good quality and properly applied. Treated roads combine many of the advantages of asphalt; are practically waterproof, afford good foothold for horses, are comparatively noiseless, while the cost of scavenging is lessened.

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STEAM PIPE SYSTEMS FOR GENERATING STATIONS

By JOHN H. RIDER

SLIGHTLY CONDENSED FROM "ELECTRICAL ENGINEERING"

The degree of excellence of the general design of an electric generating station may be gauged by the possibilities which the lay-out of the plant gives for a good arrangement of the steam pipe system. The site may be a good one from the points of view of water carriage for coal, ample water for condensing purposes, etc., but the design of the station itself, which includes the inter-relations of the various units of steam raising and steam using plant, may generally be safely judged by the steam pipe system.

The main principles underlying a good steam pipe system are eight in number, as follows:

(1) The pipes should be as short and as few as possible.

(2) The failure of any pipe should only affect one engine or one boiler (or group of boilers).

(3) The pipes should be as small in diameter as possible, to reduce with (1) the radiation losses.

(4) The pipes should be large enough to keep to a minimum the fall of pressure between the boilers and engines.

(5) The joints should be as few as possible.

(6) Proper provision must be made for water drainage.

(7) Proper provision must be made for expansion and contraction.

(8) Proper provision must be made for cutting off various sections in cases of emergency.

Taking the first principle, viz., that the pipes should be as short and as few as possible, it will be obvious that this will depend entirely upon the relative positions of the boilers and engines, and the chief feature in the design of the generating station is at once involved.

When the generating units are of comparatively small size, such as from 300 KW. to 500 KW., no difficulty will be experienced in arranging the boilers and engines in two parallel rows, the relative spaces occupied by the boilers and engines being comparable. As the generating units get larger, say from 1,500 KW. to 3,000 KW., a double row of boilers, with the firing space between them, will be found necessary, with one parallel row of engines. When turbines are used instead of reciprocating engines, the space occupied (in the direction of the length of the engine room if the turbine shafts are at right angles thereto) will be much less, and the difficulties of arranging a sufficiency of boiler power in the same length space, even with two rows of boilers, will be increased as the generating units get larger. One of the means adopted to meet this difficulty has been to build the boiler house in two or more floors, with one or two parallel rows of boilers on each. The complicated pipe system resulting is more than sufficient to condemn the design.

In the writer's opinion, one row of engines should be the maximum, and, when this cannot be supplied with sufficient steam from not more than two parallel rows of boilers in the same boiler house, the boilers should be set in blocks at right angles to the engine room, and each row of boilers should feed one generating unit through the medium of a common header. This arrangement is practically compulsory in large turbine stations.

Anything which increases the distance between the engines and boilers increases the length of steam piping required, and should be avoided wherever possible. Main flues and economizers are frequently placed behind boilers, and the engineer should carefully consider whether it would not pay in such cases to arrange the flues, etc., either below or above the boilers instead of behind them. Incidentally it may be pointed out that two expensive items in the cost of generating station buildings, viz., land and roof, may be both reduced by such expedients as placing main flues and economizers over or under boilers, and condensers in engine-room basements. In other words, it is generally cheaper to build high than wide.

The steam pipes should also be kept short by taking them directly to their work, and by avoiding all such designs as ring mains, etc. The pipes from the boilers should go directly to

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a main header, from which the pipes to the engine separators are taken. The sandwiching of the boiler and engine branches on the steam header will result in reducing the size of the header practically to the diameter of the largest branch, and give such intimate interconnection among the boilers and engines as will do away with any necessity for either duplicate pipes or ring mains. It will be seen that, by the use of valves in the header and in the boiler and engine branches, the second principle laid down, viz., that the failure of any pipe should only affect one engine or boiler (or group of boilers), is entirely met in the scheme of piping outlined above. It would be quite possible to design a system of piping by which the supply of steam from and to each boiler and engine would be quite independent of the failure of any pipe. This would mean not only a duplicate system throughout, but also double steam branches on the boilers and engines, a complication not only prohibitive in its cost, but absolutely unnecessary.

The cost of steam piping has not only to be reckoned from the point of capital expenditure, but also from the point of the cost of the coal consumed to supply the heat which is continually radiated from the pipes and valves. The annual cost of this lost heat will depend upon three things, viz., (a) the cost of coal, (b) the area of the pipe surface exposed to the air, and (c) the steam pressure or temperature. With a constant stream pressure and a fixed amount of piping in use, the radiation losses will be independent of the load upon the generating plant, and, therefore, their relative value will decrease as the load factor of the station increases.

The first item, the cost of coal, cannot be controlled by the designing engineer, and the third item, the steam pressure, is fixed by more important considerations than its effect upon the heat radiated from the steam pipes. The area of the pipe surface (or its covering) exposed to the air can, however, be controlled within limits, and to this point careful consideration should be given.

The cost of the heat lost by radiation in its effect upon the coal bill is not, however, the whole matter, as one of the most serious results is the condensation of the steam within the pipe system, and the formation of water. The question of the proper arrangements for draining condensed water away will be dealt with later, but these must be looked upon only as remedies, as it is practically impossible to find any absolute cure against the formation of water under ordinary working conditions. Water is not only bad from the point of view of loss of efficiency, it is positively dangerous, and many pipe systems and steam engines have been ruined by it.

The first thing to do is to minimize the condensation by reducing the number, length, and sizes of the pipes as far as possible, and the second to cover the whole of the pipes, valves, and flanges, with an efficient non-conductor of heat.

Too much care cannot be exercised in the choice of a pipe covering. The writer, however, has never seen the results of any tests taken on non-conducting covering after several years' work. It is not sufficient that it should still be mechanically sound. What is wanted is that it should continue to retain its non-conducting properties unimpaired. This latter point is of extreme importance, since the best coverings are those which are composed of the greatest number of minute air cells, and are, therefore, of a porous nature. Age, accompanied by vibration, frequently destroys this porosity with the result that, in a few years, the covering has lost its efficiency, and should be renewed.

Pipe covering should be of the sectional and removable type, with all flanges and valve bodies covered, and with the outside surface protected by a cover of planished steel.

Since any increase in the diameter of a pipe increases its cross-sectional area at a greater rate than its circumference, we are easily able to choose a pipe of such a size that it will pass the necessary quantity of steam without undue fall of pressure. A steam velocity up to 6,000 ft. per minute is quite practicable, and, in some cases, a velocity much greater than this is allowed. The fall of pressure in the short lengths necessary between the boilers and engines of a well-designed station may be neglected, and is not likely to be greater than 2 or 3%.

Steam pipes should be made of wrought steel with lap-welded longitudinal joints. Cast-iron and copper pipes are unsafe for high pressure, and, although the latter were at one time frequently used for bends, they have been entirely superseded by steel pipes in modern work. Branches are usually formed by means of tees, which should be made of a special tough mixture of cast steel. Where the sizes of the pipes will permit, a much better job is made by riveting the branch directly on to the pipe. In this case the branch itself is formed of steel, flanged out to fit the pipe closely, and, after double

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riveting, the joint should be carefully caulked. However well designed a steam-pipe system may be, it will usually be found to give more trouble at the joints than at any other place. The number of joints should, therefore, be kept small by using pipe lengths as long as possible. Steel pipes up to 20 ft. long are now readily obtained, but the necessary interposition of valves, tees, etc., in the pipe ranges seldom allow such long lengths to be used. A great deal can, however, be done in this direction by careful design.

Flanges should be made of steel pressed out of the solid, and be either riveted or welded in place. All flanges should be turned, both on the faces and rim, after fixing on the pipes. In the writer's opinion facing strips are unnecessary. There are various methods of making the actual joint between the pipe flanges. Corrugated gun-metal rings, with mastic cement, make, perhaps, as good a job as any, but some engineers prefer a softer and more elastic packing. Nothing should be used for jointing material which will soften under water or contract with heat, and the last word on joint-making has not yet been written, as, at the best, joints are always liable to give trouble.

More mistakes have probably been made in the design of the draining arrangements of steam-pipe systems than in any other point in connection with them. The mistakes have been due principally to a failure to appreciate properly a few simple facts relating to the flow of water in steam pipes. These are:—(a) Water, when left to itself, will always flow downhill; (b) water will flow uphill when it has a force behind it stronger than gravity; (c) steam will supply such a force.

While the use of superheated steam reduces to a minimum the risk of water forming in the steam pipes, so long as there is a rapid transference of steam from the boilers to the engines, there are nearly always certain lengths of pipe in the system which are idle. Here the steam is bound to condense if the pipes are kept "alive," and, if they are shut off, there is always a great risk of water forming in them when they are again opened to the steam.

The draining arrangements must, therefore, satisfy two conditions, viz.:—

(1) They must keep the steam-pipe system entirely free from water when no steam is passing to the engines. That is, it should be possible to open the stop valve of any engine at any time without risk of water following.

(2) Should any water form in the pipes while carrying steam to the engines, or should any water come over from the boilers, it must be prevented from (a) reaching the engines, or (b) causing "water hammer" in the pipes.

To meet the first condition, the pipes must be arranged so that all water will flow by gravity to certain defined points, where it can be collected and drained off. To meet the second condition the pipes must be arranged so that the water will flow naturally in the same direction as the travel of the steam.

The velocity of the flow of steam in modern steam-pipe system is so great (frequently over a mile per minute) that the water can only be satisfactorily trapped by passing the steam, at the lowest point of the system, and close to the engines, through large separators. Here its velocity can be lowered, and its direction of motion suddenly changed at the same time.

Next only in importance to the draining arrangement is the provision made for expansion and contraction of the steam-pipe system under varying temperatures. When first erected, and before any steam is passed through them, the temperature of the pipes and valves is that of the air of the room, say about 60° F. The temperature of saturated steam at 180-lb. pressure is about 380° F., a rise of about 320° F.; while, if superheated, the temperature is commonly taken as high as 550° F., and sometimes higher. The linear expansion of a steam pipe is about 0.000007 of its length for every degree (F.) rise, so that a rise of 320° F. means an expansion of over one-quarter of an inch on every length of 10 ft., or more than 0.2%. A corresponding contraction takes place as the temperature of the pipes is lowered. The racking strains set up by these movements would quickly break the pipe joints, and probably wreck the whole system in a short time, unless some means were adopted, not only to take up the expansion and contraction, but also to control the direction of the movement. The first is met by the provision of suitable bends, which allow the pipes to have a limited movement, and the second by anchoring or securing the pipes to the building at certain points, so that the movements of the whole system are sub-divided in proportion to the number of expansion bends provided.

The anchoring is done by the use of cast-iron stools bolted to the walls or stanchions, with heavy wrought-iron straps clamping the pipes. A slab of asbestos slate should be inserted between the stools and the steel work to which they are bolted to reduce leakage of heat. All other supports for the pipes should provide for

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free movement, and rollers are generally used. Care must be taken, when arranging the expansion bends, that they do not in any way interfere with the free draining of the pipes. U-bends should always be fixed perfectly horizontal, or they will form water pockets.

When a number of branches are taken out of a long pipe, such as the boiler and engine branches on a main header, it is not sufficient to provide expansion bends in the header. The branches must move with the header, and, if they are short, or are anchored too close to the header, the joints will quickly give out. This is frequently the case with the branches to the steam separators, as the separators are usually fixed close under or very near to the header. The engine stop-valve is bound to be a fixed point, and, in the writer's opinion, the whole of the pipe work between the engine stop-valve and the main header, including the separator, should be free to move.

This has been done by mounting the separators upon special stands with ball bearings and springs, so that each separator is free to move in any direction, either up and down or sideways. In fixing all pipe bends which may have to take up expansions and contractions, they should be sprung into place so that, at the two extremes of cold and hot, they will have moved equally either way from the natural shape when at rest.

In order to minimize the effect of any accidental stoppage of any part of the pipe work, and to give facilities for repairs, it is necessary to use a number of valves other than those immediately on the boilers and engines. Valves must be fixed in the main header between the various branches, and valves should also be fixed at the root of each branch where it leaves the header.

All valve wheels and handles should be so placed that they are readily accessible, and all valves should be of the "full-way" type, so that there is no restriction to the passage of either steam or water. The positions for valves require very careful consideration. They should never be placed at the bottom of a rising pipe such as the one leading from a separator to an engine. But if the principles of correct drainage which have been suggested are carried out the valves cannot well be otherwise than in the correct positions.

PHOSPHOR-BRONZE

By EDWIN S. SPERRY

CONDENSED FROM "THE BRASS WORLD"

The term phosphor-bronze is used to designate an alloy of copper, tin, and phosphorus, or of copper, tin, lead, and phosphorus. The phosphorus is added in small quantities with the sole object of reducing the oxide of copper that forms during melting. In fact, any phosphorus that is added over and above that required for deoxidizing the bronze is actually injurious.

Phosphor-bronze may be made in two ways: First, by introducing phosphorus into a mixture of copper and tin; second, by introducing the phosphorus into molten tin and making a phosphor-tin. This, in turn, is added to the copper and tin mixture as a carrier of the phosphorus.

The introduction of phosphorus into copper and tin while melted is open to the objection of excessive loss and danger. It is successfully done every day, however, but requires experience and care. The yellow sticks of phosphorus, kept under water to prevent spontaneous ignition, are placed in a bell-shaped arrangement of graphite called a phosphorizer, and the whole is pushed down under the surface of the molten copper. A violent ebullition takes place with much loss of phosphorus and danger to the operator. From 20 to 30% of the phosphorus burns, and the rest alloys with the copper. Tin is now added, if desired, or it may be added to the copper before the phosphorus is introduced. The result is a phosphor-bronze.

Phosphor-tin is made in the manner previously mentioned, except the phosphorus is introduced into molten tin. As tin melts at a much lower temperature than copper the introduction of phosphorus is attended with less loss and danger.

The waste of phosphorus in making phos-

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phor-tin is less than in adding it to copper. It usually wastes about 10%, but this loss depends upon the manner in which the phosphorus is added, and the heat of the tin. It is well to keep the heat of the tin as low as possible.

An alloy of tin and phorphorus containing 5% of phosphorus is usually employed. It is stable, and may be melted with very little loss. It is the best mixture of tin and phosphorus to use. In order to make it about 6 lbs. of phosphorus are introduced into 100 lbs. of tin. The loss will reduce the amount which alloys with the tin to about 5%. The phosphor-tin is cast into small bars so they may be easily broken.

Making Phosphor-bronze.—As previously mentioned, the function of the phosphorus is to remove the oxygen that is absorbed when the copper melts. The best phosphor-bronze contains just enough to do this and no more. The determination of the amount necessary to reduce the oxide of copper is quite difficult, as no two melts of copper oxidize the same. One may be heated hotter or longer than another, and thus absorb more oxygen. For a good melt, however, it has been found that about 0.05% of phosphorus is sufficient. Frequently less will answer, and if more is required the copper probably has been "burnt" in melting. In making sand castings where scrap is used, it is often advisable to add more than enough to deoxodize the copper, so that when the scrap is melted, the phosphorus will not entirely oxidize out. From 0.10 to 0.25% of phosphorus is advisable for this class of work.

The copper is melted in the usual manner, the tin is then added, and lastly the phosphor-tin. If lead is used in the mixture, it may be added after the tin. The mixture is now stirred with a plumbago stirrer, as iron will not answer. Phosphorus attacks red-hot iron with great eagerness, and a stirrer is soon dissolved. When thoroughly mixed the metal is poured into castings or ingots. Where strength is the chief consideration phosphor-bronze gives far better results in sand castings if melted twice.

Mixtures for Rolling.—Phosphor-bronze mixtures for rolling must never contain over 0.05% of phosporous. If they do they will surely crack in rolling. From 0.02 to 0.03% is usually safer. These mixtures seldom contain lead, as it renders the metal brittle and difficult to roll. The hardness and strength of the mixture depend upon the amount of tin that is used. When the tin does not exceed 8% the metal will roll. But with such a high percentage of tin rolling is quite difficult, and is only used for chain metals or similar strong alloys. For ordinary use the in content runs from 3 to 5%, depending upon the requirements.

Phosphor-bronze Spring Mixture.—One of the principal uses of phosphor-bronze sheet and wire is in the form of springs. Inasmuch as it does not contain zinc, the springs do not crystallize in service. Zinc should never be added to a phosphor-bronze when a good metal is desired. It cheapens it, but injures its strength. A good mixture for phosphor-bronze springs consists of the following:

Copper	95 lbs.
Tin	4½ lbs.
5% phosphor-tin	½ lb.

While hard this mixture will roll successfully if good copper and tin are used. Less tin will give a softer mixture. No matter how the tin is changed to meet a requirement the phosphor-tin must remain the same. Neither increase nor reduce it.

Sand Castings for Strength.—While phosphor-bronze cannot equal some of the other bronzes for strength, its good casting qualities render it a satisfactory material to use. It is, however, much superior to all gun-metal and the well-known 88-10-2 mixture. In order to produce strong phosphor-bronze castings, however, it is necessary to keep the phosphorus low. I have obtained excellent results with a phosphorus content of 0.05%. A larger quantity reduces the strength in the proportion that it is increased. With the 0.05%, however, the metal cannot be melted over as many times as it can with a greater quantity.

For phosphor-bronze castings of the highest possible strength the following mixture is excellent:

Copper	90 lbs.
Tin	9 lbs.
5% phosphor-tin	1 lb.

The mixture is made according to this formula, poured into ingots and then remelted and poured into sand castings. The remelting increases the strength. For ordinary purposes, where the utmost strength is not required, the second melting may be dispensed with. Sand castings made in green-sand molds from the previous mixture will give from 40,000 lbs. to 50,000 lbs. per square inch tensile strength. If more ductility is required the amount of tin may be decreased and more will render it less ductile. The amount of phosphor-tin should not be changed.

For ordinary work where a medium strength is required, and when the scrap must be used

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over and over again, the following mixture is recommended:

Copper	90 lbs.
Tin	8 lbs.
5% phosphor-tin	2 lbs.

The scrap from this mixture may be used over and over again with good results. The metal casts well, and is stronger than gun-metal. In making strong phosphor-bronze the best copper and tin should be used, and the phosphor-tin must be free from lead. Lake copper and Straits tin give the best results.

Bearing Mixtures.—Phosphor-bronze for use as bearings must always contain lead (except in the case of roll-neck brasses, which should contain very little or none at all). It is lead that gives the bearing its good anti-frictional qualities. The phosphorus prevents the separation of the lead. Lead may be present in the mixture up to 15%, but the majority of makers use less. Tin must be used in the mixture with the lead in order to prevent its separation. A good general mixture for phosphor-bronze bearings, and one which the test of time has proved to be so, is the following:

Cooper	80 lbs.
Tin	8 lbs.
Lead	10 lbs.
5% phosphor-tin	2 lbs.

Points to be Noted.—Zinc should never be present in phosphor-bronze. It causes liquation and the accompanying formation of "tin-spots" in a marked degree. These are small, hard, white masses in the interior of the casting. They are so hard that a file will frequently not touch them. They are really the liquation (separation) of an alloy of copper, tin, and phosphorus different from the parent mixture. The excess of phosphorus in such mixtures is the cause of it.

If a brass founder would keep the content of phosphorus down in the mixtures to that previously given, and not add any zinc he would be able to make phosphor-bronze castings that would equal any now produced. These two points are really the secret of success.

NOTES ON REINFORCED CONCRETE WORK*

By H. H. FOX

To make the best possible reinforced concrete it is necessary:

1. That the forms should be strongly built, smoothly finished, as nearly as possible watertight, and left in place until the concrete is self-supporting.

2. That the reinforcement should be designed to relieve the concrete of all stresses which concrete cannot safely withstand, and to be amply protected from fire and weather by concrete on all sides; that the reinforcement should be so securely fixed in place before concreting that the concreting will not disturb it.

3. That the concrete should be mixed and placed in such a way that the final production will be homogeneous and without voids.

First.—Forms should be built of matched and dressed lumber and should be greased to make them part easily from the concrete. The length of time which should be allowed to elapse before removing forms depends upon two factors—the weather, and the load to which the member in question will be subjected upon removal of the forms. The fact that the concrete sets more rapidly the warmer the weather needs no elaboration. It is, however, never out of place to utter a warning against taking risks with concrete in cold weather. Scratching concrete with a knife gives one a rough idea of its strength providing one scratches often enough to become thoroughly familiar with the behavior of concrete under the knife. In general the nearer the load to be sustained approaches the load for which the member was designed, the longer the forms must remain. Thus the forms for an overhanging cornice should remain in place longer than the forms for almost any other member, because the dead weight of the cornice is a very large percentage of the total weight which it is designed to carry. By similar reasoning, roof forms should remain longer than floor forms, floor forms longer than column forms, column forms in the top story of a building longer than column forms in a lower story, and column forms in general longer than footing forms.

It is very important that forms should be

*From a paper entitled "Reinforced Concrete from the Contractor's Standpoint," read before the National Association of Cement Users, Buffalo, Jan. 24, 1908.

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so designed that the column forms may be removed without in any way disturbing the supports of the beams and girders bearing on these columns. In this way a defect in a column may be detected and remedied before any load is brought to bear upon the column. In removing beam and girder forms, the posts should be removed from only one beam or girder at a time, and as soon as the form for this beam or girder is removed, the posts should be immediately replaced. By this procedure, danger of failure of concrete through poor workmanship is much diminished, as a defective member is supported by the members on either side of it until the defect may be remedied. The practice of removing all the posts under a floor at the end of a given period—one, two or three weeks—without pausing to remove the forms one at a time, examine the workmanship, and replace the posts, cannot be too strongly condemned; both because of the possibility of defective workmanship, and because the concrete floor, even if not defective, may not be strong enough to carry in addition to its own weight the weight of the one or two floors which may, by the time the forms are removed, have been constructed above it.

There is less danger in taking down column forms when the concrete is 36 hours old, and floor forms when the concrete is five days old, if the posts of each member are removed separately, and as soon as possible replaced, than there is in knocking out all the posts under a large piece of floor in three weeks.

Stirrups should touch the forms only in two points and be, therefore, well protected against fire. The stirrups should not be relied upon to support the tension bars in place, but hangers should be used. As these hangers are of no further value after the concrete is in place, the fact that they are supported directly on the forms, and are thus not fireproofed, is of no importance. The middle portion of tension bars in beams and girders is thus held in place by hangers; the ends are held in place by being laced with wire to one another and to the vertical reinforcement in the columns. The bars in the floor slab are supported off the forms as follows: In order to obtain continuous action over beams every alternate tension bar in the floor slab is sprung up where it crosses a beam, being supported at the edge of each beam by a short piece of band iron about 1½ ins. narrower than the thickness of the floor slab, and bent to an angle of about 60°, so that it will stand on edge by itself. In the middle of each span a bar runs at right angles to the tension bars, on top of the tension bars, and is held at any desired distance above the floor by staples into the floor cover and by the lifting tendency of the tension bars which are sprung up over the beams. The other tension bars are then raised from the floor by lacing them with wire to this central bar.

To insure fireproofing in columns, four sticks are used in tamping the concrete columns, and these sticks are run down one on each side of the column between the hoop or spiral reinforcement and the form, thus insuring an amount of fireproofing equal at least to the thickness of the stick. The vertical reinforcement is placed inside the hoop or spiral reinforcement.

Concrete should not, unless it is absolutely necessary, be dumped from a wheelbarrow directly against the form, but should be dumped on the soft concrete already in place. The mortar, flowing more freely than the stone, keeps always ahead of the mass, and stones falling in this mortar find a perfect bed; whereas if a barrowful of concrete is dumped into a dry beam the stones may become jammed between the forms and the steel and form a pocket into which the mortar will not enter.

In concreting columns it is necessary to proceed slowly at the bottom of the column and to tamp the first foot with great care. After the mortar flushes to the surface over the entire section of the column, there is little danger of voids being left in the part of the column above the first foot if a sufficiently wet mixture is used. Walls should be similarly handled.

An exterior column is usually made square for architectural reasons. An interior column is octagonal, partly for architectural reasons, partly to save concrete. This saving is due to the fact that in a column reinforced with a spiral, the concrete outside the spiral is not figured in adding compressive strength to the column; and therefore, if this column is square, the concrete in its four corners is wasted.

Two sides of the columns are held together by bolts; the two opposite sides, by hardwood wedges between the bolt and the form as close as possible to the end of the bolt. In some cases the sides are made up of narrow strips. This is to facilitate the reduction in size of the columns from floor to floor. In warm weather there is no need of having more column forms than one complete set for one story, even when work is progressing at the rate of a story in five or six days. In a ten-story building each column form is then used

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ten times, once in each story. Each of these narrow strips represents the reduction in diameter of the column from one story to the next. The outside and inside of the exterior column form are not made up of narrow strips for the reason that exterior columns are usually the same width from basement to roof. To reduce the section of an exterior column, only the thickness is reduced.

In removing forms the column forms are first removed. Next, the posts are taken from under the girder. The girder bottom then drops and the posts are immediately replaced. The nails are drawn from the key, which is nailed only to the girder side; the key is knocked out, the posts are taken from under the beam, the so-called "spreaders" are knocked from under the cover, and the beam form comes down in one piece. The girder sides, which are beveled at the ends, come out easily as does also the cover, which is beveled on all four edges.

In warm weather, with a complete set of forms for one story, a speed of construction of one story in eight or nine working days may be attained. With one complete set of column forms and a set and a half of floor forms, a speed of a story a week may be attained. The size of the building in plan makes very little difference.

SPEED REGULATION OF HIGH-HEAD IMPULSE WATER WHEELS

By H. S. KNOWLTON

FROM "THE ENGINEERING AND MINING JOURNAL"

The speed regulation of high pressure impulse wheels with deflecting nozzles is the easiest problem in governor engineering. A small regulator developing from 2,500 to 7,000 ft. lbs. is powerful enough for the largest units. These governors should be of the oil-pressure type. Such machines may be wholly self-contained. The connections between the governor and the nozzle are simple and inexpensive, and the degree of speed regulation is about the same as with a steam engine. The problem of getting the best possible speed regulation from a high-pressure turbine or an impulse wheel with needle valve control at the end of a long pipe line is troublesome on account of the fact that the inertia of a long column of water cannot be changed with sufficient rapidity. A 5-ft. pipe line 5,000 feet long, with a maximum inflow of 8 ft. per second, and a head of 400 ft. gives theoretically an output of 5,600 HP. The actual weight of water in the pipe would be over 3,000 tons, which exceeds that of a loaded freight train half a mile long. It would be a difficult matter to bring such a train from rest to a speed of 8 ft. per second, or stop it from that speed within a second or two, yet this is just what some engineers expect can be done with an equivalent water column.

While it is impossible to determine the actual initial rise of pressure caused by a sudden closing of the turbine gates, the matter is made even more complex by pressure waves, which, originating near the gate, travel back and forth through the water with the velocity of sound, setting the whole mass into vibration like an organ pipe. The stress may be greatest near the middle, and the need of a relief valve is apparent. The valves must move to the required position without oscillation in order to be effective, and must also open quickly. The time of closing must be long compared with the vibration pitch of the water column. The latter requirement is rather difficult with pipe lines several miles long. Special valves are now built which will open instantly and consume several minutes in closing, the speed of action being adjustable.

Though it is possible to prevent excessive rise in pressure due to reduction in velocity of long water columns, no means has been devised to produce quick acceleration of the water, when, because of sudden increase of load, the speed of the turbine begins to fall. It may be several seconds before the water accelerates enough to supply the turbine's needs. Then the speed may be brought back on the

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other side of normal because of excessive gate opening. When the governor is made to act without oscillations which will encourage increased pressure vibration in the water column, the speed regulation will be poor if the load changes are sudden and large; it is impossible for this to be otherwise, because the water column cannot possibly alter the energy given to the wheel fast enough, whether the gates be in one position or another. The only complete remedy for the troubles in speed regulation caused by the excessive inertia of a water column is some form of by-pass valve directly connected with the water-wheel gates, arranged to open as the gates close and thus keep the velocity of the column nearly constant. This involves a frequent waste of water equal to that required for the largest load variations, and cannot well be permitted in many installations. The compromise is to sacrifice part of the speed regulation for the sake of water economy. Frequently such stations are connected electrically with others where the hydraulic conditions are favorable to good speed regulation, which insures the even speed of the whole system with good efficiency.

CAISSON DISEASE

The recently issued British "Report of the Health of the Navy" contains an interesting memorandum prepared by Staff Surgeon-General Rees on the subject of "Caisson Disease," an abstract of which is given herewith. The memorandum deals chiefly with the disease so far as it affects divers, but is also aplicable to all cases where compressed air is used.

As a diver descends in the water, air is pumped to him by means of an air pump, which keeps the air pressure in the helmet approximately equal to the water pressure at the level of the exhaust valve of the helmet. It is seldom that a caisson worker is subjected to a greater pressure of air than 40 lbs., while the diver at 35 fathoms is exposed to a pressure of 93.6 lbs. per square inch.

A gas in contact with a liquid on which it has no chemical action is absorbed by the liquid in amounts proportional to the pressure under which the gas is at the time. In the lungs the air is practically in contact with the blood. In a mixture of gases each gas is absorbed by the fluid as if it alone were present. Each of the gases forming the mixture of atmospheric air, viz., oxygen, nitrogen, and carbon dioxide, is absorbed in accordance with this law, but the oxygen is used up by the tissues, and the ventilation of the lungs is such that the CO_2 is kept at a fixed percentage, no matter what amount is present in the air breathed. The nitrogen is absorbed unaltered, and in an amount in direct proportion to the pressure. Dr. Hill has shown by experiment that the amount of nitrogen absorbed by the blood under pressure conforms to Dalton's law. So long as the diver remains under pressure there is no manifestation of the presence of the absorbed gas, but as soon as the pressure is released, that is, the gas should begin to bubble off. Fortunately, the blood is a sticky albuminous fluid in which bubbles do not easily form, and is capable of being supersaturated with nitrogen to twice its normal amount without the formation of bubbles. It has been found recently that fat can take up six times the amount of nitrogen that the same weight of blood can absorb.

The comparative freedom of the diver from attacks of "the bends" is probably accounted for by the fact that his blood never becomes saturated, owing to the limited time he is exposed to compression.

The relative immunity of divers to caisson disease varies. Dr. Snell has pointed out how much more liable the old are than the young to illness from this cause. In cases collected by him, the percentage ratio of illness at each age was as follows:

Age.	Per cent. of illness.
20-25	10.3
25-30	24.3
30-35	20.9
35-40	22.9
40-45	26.3

The increase in the percentage of those attacked by the disease after the age of 45 is so excessive as to make it extremely dangerous to employ men who have reached that age.

The following table, compiled by Mr. A. Smith, indicates the influence of bodily habit on health:

	Spare.	Medium.	Heavy.
Men who lost little or no time from sickness	25	14	3
Men taken sick.....	26	22	36
Men paralyzed	2	3	5
Men died	—	—	3

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These figures suggest the desirability of eliminating fat men from those exposed to compressed air, and are in accordance with the results to be expected from a scientific study of the disease. A man who carries about with him a huge reservoir for nitrogen as is provided by the abdominal fat, must be more liable to the formation of bubbles than the thin, spare man. In fatal cases after sudden decompression bubbles have been found in the abdominal fat when there were none found in other tissues.

Safety in decompression may be secured by two methods: (1) Limiting the time of the exposure; (2) by bringing the diver up slowly. In caisson work it has been found that by limiting the time of the exposure to the compressed air, cases of paralysis have been practically eliminated.

Various rates of decompression have been suggested. Paul Best recommended a rate of twelve minutes for each atmosphere of pressure; Hiller, Meyer, and Von Schrötter, twenty minutes per atmosphere; and Hill and Macleod the same rate. The blood, as it leaves the left side of the heart, is always saturated with air to the existing pressure, and, in the same way, will be desaturated to the same pressure. The blood leaves the arteries in less than half a minute, and in this time bubbles scarcely seem to form, so that there will be little risk of their actual formation in the arterial blood unless ebullition is practically instantaneous. With very rapid decompression, however, small bubbles which have passed through the capillaries of the lungs may easily increase in size in the arteries.

If we had only to consider the saturation of the blood by nitrogen, the problem of safe compression would be easily solved. The whole of the blood passes through the lungs once a minute, and as it is at once desaturated to the existing pressure, all danger would pass away one minute after sudden decompression.

Unfortunately, the problem is much more complex, as the saturation of the tissues has to be considered. Experience shows that cases of accident are almost non-existent when the air pressure is less than 20 lbs. plus, and it would seem that this immunity is due to the fact that bubbles will not readily form as long as the relative diminution of pressure is kept at a ratio of 1-2. In coming up from—

33 ft. to the surface.
or from 99 ft. to 33 ft.
" 165 ft. to 66 ft.
" 231 ft. to 99 ft.

there should be no formation of bubbles, and that, generally, decompression can be safely proceeded with if the difference between the relative pressures of the air and nitrogen dissolved in the blood and tissues is not more than in the proportion of about 2 to 1. This assumption is of great practical importance, as desaturation will naturally go on faster the greater the relative difference we can establish without undue risk. In gradual and equal decompression the absolute difference between the air pressure and the nitrogen pressure in the tissues necessarily goes on increasing, and is greatest at the end of the process. When we take into consideration that it is the relative, and not the absolute, difference in the nitrogen pressure that matters, the unsuitability of uniform decompression becomes more evident.

Acting on the above consideration, scheme of decompression of the diver in stages has been drawn up. Many experiments have been carried out at the Lister Institute by Dr. Boycott and Lieut. Damant, R. N., to compare the two methods of decompression, and the great advantage of the "stage" method has been conclusively proved.

It was found that the time required to desaturate a diver who was completely saturated with nitrogen at 41 lbs. pressure (95 ft.) was at least 90 minutes. In 30 fathoms, or 80 lbs., 3¼ hours would be required. Such a length of time is impossible for the diver, so it was found necessary to limit the extent of saturation. A table has been prepared giving a scale of times that divers may be allowed to stay in deep water.

Bubbles once formed in any tissue of the body are liable to increase in size as long as the pressure of nitrogen in that tissue is greater than that of the air. This will account for the fact that symptoms may go on increasing in intensity for two or three hours after decompression.

Although Dr. Rees's memorandum deals primarily with caisson disease as affecting deep sea divers, the conclusions of the committee, which he summarizes, apply in like manner to the conditions obtaining in caisson and other forms of compressed air working.

The researches of Drs. Hill, Haldane and Greenwood, Lieut. Damant and others have completely revolutionized the practice of compressed air working in the last few years. It is now possible to carry out operations under air pressures and at depths formerly out of the question, provided due precautions and

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suitable methods of working are adopted. Lieut. Damant, the recently appointed British naval inspector of diving, has descended to a depth of 210 ft. without detriment to health. This depth undoubtedly constitutes a record in diving work.—"The Engineer" (London).

THE DESTRUCTION OF TAR IN GAS PRODUCERS

By H. P. BELL, M. A., F. C. S.

CONDENSED FROM "ENGINEERING"

The manufacture of producer gas was, during the earlier part of its history, essentially a process for the economical consumption of fuel in heating furnaces or boilers. Under these circumstances the use of any considerable purifying plant was not only unnecessary, but generally even undesirable, since by conveying the gas direct from the generator to the furnace its sensible heat could be turned to account. When cheap gas came to be required for internal-combustion engines it was found convenient to make it from coke or anthracite, which, as they yield only comparatively small quantities of tar or other residuals, did not necessitate the use of any very extensive purifying plant. With a rapidly increased demand for producer gas it became necessary to use a cheaper and more accessible fuel than coke or anthracite, and since this increased demand was to a large extent for power gas, the purification of the gas became a matter of great importance.

The advantages of bituminous coal, as compared with anthracite or coke, in making producer gas, are not, of course, confined to its cheapness and the wide area from which it can be obtained, for the volatile constituents of such coals may also be made a source of advantage. Those volatile constituents vary considerably both in quantity and in composition, but, generally speaking, the calorific value of the gaseous hydrocarbons distilled from bituminous coal is about 20% of the total calorific value of the coal. Owing to the high calorific value per cubic foot of this gas, it enriches the total gas made from the coal in such a way that, while the quantity of heat in the gas produced from a given quantity of the coal may be no greater than that from a similar quantity of coke or anthracite, this heat is carried in a smaller volume of gas—a saving of bulk which is, in many cases, of some importance. As a fact, there should, with suitable plant, be an increased economy in gas-making, since the distilled gas is produced with proportionately less expenditure of heat than the gas from an equivalent quantity of carbon; and it should be the aim of designers of producer-plant for bituminous fuel to produce either a richer gas, with no decrease in economy, or an increased economy, with no loss of calorific value. In any case, producer-gas, which first gained a footing as a gas made from coke or anthracite, will in future have to make its way chiefly as a gas made from bituminous fuel.

Of the troubles which are due to the presence of tar in large quantities, one—the caking of the fuel—is similar in effect, and has to be treated, if at all, in a similar way to the formation of clinker, which is common to all kinds of coal. The distinctive feature of bituminous coal is the large quantity of tar which is carried over with the gas, and this tar must be separated from it before the gas can be used in internal-combustion engines. The tar frequently amounts to 4 or 5%, and may be as high as 15% of the coal. To effect the separation rather bulky and expensive plant is required; and it is only in cases where gas is produced in very large quantities that any satisfactory return can be got from tar. Besides the cost of the space which is occupied by the recovery plant, and of the labor which is required in connection with it, the recovery of residuals involves the introduction into engineering works of a new and quite foreign trade, for a plant of this class is in many cases essentially a chemical plant, yielding producer-gas as a by-product.

There are two practicable methods by which tar may be destroyed; complete combustion with air, and decomposition at a high tempera-

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ture. In the first case, that of complete combustion, the products—carbonic acid and water vapor—must, for the sake of economy, be reduced to carbon monoxide and hydrogen by passing them over hot coke. (The word "coke," in discussing matters of this kind, must be used in its widest sense, meaning the carbonaceous residue from the distillation of any kind of bituminous coal. It may be a sandy substance without cohesion, and it may contain more ash than carbon; it practically always contains appreciable quantities of bituminous substances.) In the second case the tarry vapors are passed directly over hot coke, or through heated regenerators, and are thereby broken up into, on the one hand, gases such as marsh gas, ethylene, etc., with carbon monoxide and hydrogen; on the other hand, into heavy hydrocarbons and carbon. The heavy hydrocarbons are for the most part burnt with the coke, so that the general statement is approximately true, that the tarry vapors are decomposed into fixed gases and carbon.

In favor of the first method it has been urged, on the one hand, that it is only by combustion that the tar can be completely destroyed, but this involves the separation of the whole of the tarry vapors, which is hardly possible, since even gas made from coke contains tar. On the other hand, this method must result in impoverishing the producer gas, since the volatile gases of the coal are burnt with the tarry vapors; so that with a really efficient plant working on this principle the final gas will consist only of carbon monoxide, hydrogen, and nitrogen, just as if the gas were made from entirely non-bituminous fuel. This method then, while it may go far towards overcoming the defects, takes no advantage of the merits of bituminous fuel. The second method preserves most of the valuable distilled gases, and consequently yields a richer gas, even if the destruction of tar is less perfect. In any case complete destruction of tar is hardly practicable even under experimental conditions; some kind of cleaning plant will always be required —at any rate, if the gas is to be used in internal-combustion engines, and the most that can be looked for is a reduction of this plant to the smallest possible dimensions.

In both methods the gases or vapors are passed through hot coke, and it is therefore necessary to provide for the maintenance of a temperature high enough to effect the required chemical actions, and of a column of coke long enough to make these actions complete. If, as is usually the case, the temperature is maintained by mixing air with the gases as they pass through the coke, some combustion of the gases with the air will occur; the desired reduction will only go as far as a point of equilibrium, depending on the proportion of air present, and the resulting gas will contain more or less carbonic acid and water vapor due to this combustion. It is therefore desirable to keep as low as possible the quantity of air which is allowed to come in contact with the hot gases.

To avoid the use of two kinds of fuel, it is clearly advantageous to use, for the reduction of the tar, the coke which is made in the producer by distillation of bituminous coal; and it is desirable to avoid any transference of this coke from one part to another of the plant, on account, not only of the labor, but of the loss of heat which is involved.

The complete distillation of the bituminous matter from coal is a process which requires the application of a high temperature—800° C. (1,470° F.) and upwards—for a considerable time. The time which is available for distillation in a gas-producer is that which elapses after the introduction of fresh fuel before it enters the zone of combustion; and in nearly all the single-chamber producers which have been described, it is evident that, when the fuel has settled down to the neighborhood of the gas-outlet, or to a place in which it is in direct communication with the gas-outlet, any tarry vapors distilled from it will pass off with the gas without any chance of destruction. The use of a second chamber seems, therefore, indispensable for complete tar destruction. As, however, coke of any kind always yields more or less tar, the production of an absolutely tar-free gas would involve the use in the second chamber of entirely non-bituminous carbon, to which the nearest practicable approach would be got by using wood charcoal.

Further, since distillation is continued into the zone of combustion, where gasification of carbon goes on, the combustion of the tarry distillates involves the combustion of a large part, if not the whole, of the gases with which they are mixed; indeed, the production of really tar-free combustible gas requires the combustion of the whole of the gases from a generator followed by the reduction of the products of combustion. This means that the whole of the heat of the fuel must be made sensible in the producer, and the loss of heat from any apparatus increases with the quantity of sensible heat which is produced in it.

It may be conceded that the method of decomposition without combustion cannot effect

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the destruction of the whole of the tar from bituminous coal; it seems evident from what has already been said that such complete destruction is very difficult even by the method of combustion, and it is practically certain that really complete destruction has never been achieved with any kind of producer-plant. The tar may be so reduced in quantity that only a small purifying plant need be used, but there is little doubt that in some cases too small a purifying plant is provided. A considerable length of gas main is not quite inefficient as a purifying apparatus, and it sometimes has to serve this purpose. The tar-destroying efficiency of a producer plant must, therefore, be judged by testing the gas as it leaves the plant, not at the engines, which may be some distance away. It is obvious that, if the combustion of the distillates is incomplete, it will be confined to the fixed gases, which are the most useful, and the lighter hydrocarbons, which are the least objectionable of the distillates; the heaviest hydrocarbons, the presence of which is the most serious drawback to the use of producer gas, will be the last to be burnt.

The method of simple decomposition of tar has the advantage which must be set off against any deficiences in tar-destruction, that the gaseous hydrocarbons, which are distilled from bituminous coal, are not destroyed, and that their quantity is actually increased by the addition of similar compounds resulting from the decomposition of the tar. Besides this, the proportion of nitrogen in the gas can be kept to lower limits, owing to the fact that no air is used for secondary combustion, and the generation of sensible heat need be no greater than is necessary for the chemical actions which have to take place in the producer, and for the inevitable losses by radiation and conduction.

It is quite likely that no type of producer can be devised which will be the most suitable for all purposes, and the same may be true of methods of tar-destruction. For purposes, however, for which freedom from tar is important, calorific value is usually also important, and for all heating purposes gaseous hydrocarbons are as suitable as any other gas. It has been said that poor gas is better adapted than rich gas for use in internal-combustion engines, because it is more capable of standing high compression without premature explosion. As a general statement this is not true, though it is true if enrichment of the gas can only be carried out by the addition of hydrogen. Explosion engines require a gas with a high flame temperature, for which a high calorific value is necessary, and producer gas enriched by the addition of hydrocarbon distilled from coal is quite capable of standing high compression without premature explosion.

THE INFLUENCE OF GYPSUM AND CHLORIDE OF CALCIUM ON THE SETTING OF PORTLAND CEMENT

By R. C. CARPENTER

CONDENSED FROM "CONCRETE AND CONSTRUCTIONAL ENGINEERING."

Portland cement when mixed with water has two important properties pertaining to the hardening process. The one that marks the preliminary process during which the mortar becomes pasty and brittle is termed the "setting"; the other, which is slow, long-continued and permanent, the "hardening." The "setting" is thought to be due to the formation of a saturated solution of alumina compounds, as aluminate of lime and similar compounds, from which crystals are deposited. The hardening process which takes place later is largely due to the formation of crystals of silica compounds, as trisilicate of lime, which are interlaced with crystals of other compositions.

In many instances the setting, which is the initial process of hardening, takes place so rapidly as to present practical difficulties in the proper gaging and use of the cement. To overcome these difficulties it has been customary to mix with the cement some material which would retard the formation of the crystals of aluminate of lime and similar compounds, and thus regulate the time of setting.

For this purpose, gypsum (sulphate of lime, $CaSO_4$) has been principally used. The effect of adding gypsum is only temporary, provided the cement is exposed to the air, and for that reason other materials have been sought for. The present article gives a brief description of some experiments recently made in the Mechanical Laboratory at Cornell University by Walter H. Kniskern and William L. Gass, for the purpose of determining the regulating power on the setting of cement of gypsum and chloride of calcium ($CaCl_2$).

For the purposes of the experiment, one of the large Portland cement works supplied us with clinker which had not been treated, and which, in its normal condition, made a remarkably quick-setting cement. This clinker was ground in a pebble mill owned by the Laboratory, under conditions which permitted the addition of the various materials to be tested.

The following shows in tabular form the results of adding different amounts of gypsum, the gypsum being proportioned by weight, as indicated in the first column of the table. In these experiments the time of initial set is taken as the time when a pat of the cement made by mixing with the percentage of water shown would bear a rod with diameter of $\frac{1}{12}$ in., carrying a weight of ¼ lb. The time of final set is taken as that time which has elapsed since mixing, when the pat will bear a rod $\frac{1}{24}$ in. in diameter, carrying a weight of 1 lb. This method of determining the set depends to some extent on the judgment of the operator, naturally giving results which are somewhat irregular, although sufficiently accurate for purposes of comparison.

The following table shows the retardation of the set due to using different quantities of gypsum:

Per Cent. $CaSO_4$	Per Cent. Water.	Initial Set Min.	Final Set Min.
0.0	29.8	2.0	52
0.5	27.6	6	87
1.5	22.1	80	157
2.0	22.1	24	114
2.5	23.7	29	79
3.0	22.1	30	69
3.5	22.1	27	72
4.0	24.2	28	45
4.5	25.4	22	40
5.0	25.4	27	59
5.5	25.4	20	78
6.0	24.2	19	37
6.5	23.7	22	40
7.0	25.4	18	59

The results of the trials with gypsum show that 1½% produces the maximum effect in retarding the set, and that for the special samples tested no beneficial results were obtained by the use of a large amount.

Although the experiments above show that a maximum retarding effect was produced by the sulphate of lime when less than 2% was ground with the clinker, it is quite certain from previous experiments that, with Portland cement of different composition, or having been burned differently, more gypsum would have been required for maximum effect.

As showing the temporary effect of gypsum in regulating the set, the following experiments are quoted from Candlot when cement is mixed with fresh water:

INFLUENCE OF TIME ON THE SET OF CEMENTS MIXED WITH SULPHATE OF LIME (GYPSUM).

Per cent. of Gypsum.	Time on Trial.	Initial H.	Initial M.	Final H.	Final M.
3	Day of Mixture...	1	0	7	0
3	4 days after.....	0	5	2	15
3	7 days after.....	0	5	0	20
3	11 days after.....	0	8	0	30
3	15 days after.....	0	5	0	30
3	19 days after.....	0	7	0	35
3	24 days after.....	0	5	0	25
3	32 days after.....	0	10	0	30
3	41 days after.....	0	45	5	30
2	Day of Mixture...	5	0	19	0
2	12 days after.....	4	40	14	0
2	21 days after.....	0	18	0	50
1	Day of Mixture...	5	30	8	30
1	8 days after.....	0	18	2	30
1	15 days after.....	0	11	0	20
1	Day of Mixture...	6	0	9	30
1	8 days after.....	4	30	8	0
1	15 days after.....	0	15	0	30
1	30 days after.....	0	0	7	00

The above tests were made when the cement was exposed to the action of the air.

Candlot kept the cement mixed with 2% of gypsum, in a very close bin, with the following results:

	Time of set Initial H.	Initial M.	Final H.	Final M.
Day of mixture.....	3	0	6	25
After one month.....	2	50	5	0
	H.	M.	H.	M.
After two months.....	1	30	7	0
After five months.....	0	10	0	18

The addition of small quantities of sulphate of lime increases the strength, except when

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the cement is immersed in sea-water and the proportion of sulphate is greater than 2%, in which case the briquettes soon show traces of alteration, and in time completely disintegrate.

The experiments quoted are conclusive in showing that there is little or no advantage gained in adding more sulphate of lime than 2%, and I believe that it would not be an unreasonable requirement in specifications to call for such a limitation.

Experiments made by Candlot and verified in the Mechanical Laboratory of Sibley College, Cornell University, indicate that an addition of 2 to 4% of slacked lime or hydrate of lime added to a cement containing a small percentage of gypsum, which has through the influence of time lost its effect in retarding the cement, will restore the slow-setting properties.*

	Time of set—Initial H. M.	Final H. M.
*Cement containing 2% of gypsum	0 20	2 30
Same cement to which has been added 2% of lime.....	6 0	10 0
Cement containing 1% of gypsum.	0 10	0 20
Same cement with 2% of lime added	1 0	8 0
Test made in Sibley College Laboratory of sample.		
Containing 2% of sulphate.....	0 12	0 15
Same cement with 5% of lime hydrate added	2 0	5 0

From 2 to 5% of lime hydrate will be found useful for retarding the setting of cement to which gypsum has been added, but which has lost the effect. The additional lime does not detract from the strength, as, in the case of the last-named cement, its initial strength, neat, was as follows:—24 hours, 360 lbs.; 1 week, 757 lbs.; 1 month, 871 lbs.

The addition of hydrate of lime without the addition of the sulphate of lime seems to have little or no effect on the time of setting, as shown by experiments made by Kniskern and Gass.

INFLUENCE OF CHLORIDE OF CALCIUM IN THE SETTING AND HARDENING OF PORTLAND CEMENT MORTARS.

The investigations of E. Candlot as recorded in his work on "Ciments et Chaux Hydrauliques," show that when Portland cement is gaged with a feeble solution of chloride of calcium, it has the effect of greatly retarding the time of setting; but when the Portland cement is gaged with a concentrated solution of chloride of calcium—as, for instance, 100 to 400 grammes per litre—it acts in a contrary manner, and tends to increase the rapidity of setting. Candlot gives the following table as showing the results of his experiments:

TIME OF SETTING NEAT CEMENT.

Solution of $CaCl_2$ Gr. per Litre	(1) H. M.	(2) H. M.	(3) H. M.	(4) H. M.
2	0 5	1 5	8 0	1 34
5	0 8	10 0	12 0	2 0
10	8 18	10 0	14 0	5 50
20	1 0	12 0	10 30	8 0
40	4 35	8 0	6 30	8 35
80	3 20	6 0	4 0	6 0
100	0 3	0 20	0 30	3 30
200	0 3	0 9	0 5	0 25
300	0 2	0 8	0 3	0 5

Candlot explains the action of the chloride of calcium by showing that a feeble solution of chloride of calcium tends to retard the solution of those alumina salts which, on crystallizing, cause the material to set. The feeble solutions have no appreciable influence on cements which do not contain alumina. In case the concentrated solution of chloride of calcium is used for gaging, the aluminate of lime is attacked very energetically, which thus causes a very rapid set, as indicated by the experiments given above.

Candlot has also pointed out that a concentrated solution of chloride of calcium tends to harden Portland cement very rapidly, and causes the tensile strength to reach a maximum quickly, the cement made in that way at the end of the year being good and sound.

Messrs. Kniskern and Gass, in the Sibley Laboratory, ground different percentages of chloride of calcium with cement clinker, and afterwards made pats, using in each case simply enough water to give the material its normal consistency for this purpose. Their results show that the chloride of calcium had great effect in retarding the time of setting, and exerted the greatest effect when about one-half of 1% by weight of the chloride of calcium was employed. On account of the water required, 1% of the chloride of calcium would correspond approximately to gaging with a solution of 30 grammes per litre in the previous experiments quoted:

$CaCl_2$ GROUND DRY WITH THE CLINKER.

Per Cent. of $CaCl_2$	Per Cent. of Water	Initial Set.	Final Set.
0.0	29.8	2.0m.....	52m.
0.5	34.1	115	274
1.0	29.8	160	272
1.5	26.4	167	234
2.0	25.4	127	212
2.5	26.4	103	180
3.0	26.4	45	182
3.5	26.4	97	185
4.5	28.6	63	150
5.0	29.8	73	160
5.5	29.8	76	84
6.0	29.8	68	145

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The experiments quoted indicate that chloride of calcium added in small percentages, either to the ground clinker as a powder or mixed with the water for gaging, has an important effect in extending the time of setting of Portland cement, and, so far as the investigations which are accessible show, it does not have any detrimental effect on the permanent strength and hardness.

Chloride of calcium is a deliquescent material which rapidly absorbs moisture, and it is possible that if ground dry with the Portland cement clinker, even to the amount of ½%, it would cause the material to gather dampness, and thus have a bad effect. The chloride of calcium solution can be added readily by adding it to the water used in gaging, since it dissolves with extreme rapidity. The experiments indicate that the set can be controlled by using less than ½%, which would be something less than two pounds to the barrel of Portland cement. Investigations are still necessary for determining whether the effect of chloride of calcium added to the cement before grinding is permanent in its effects, and whether, if ground with the cement clinker, it would exert any detrimental effect.

ECONOMIZERS

By W. W. MELVILLE, M. I. M. E.

CONDENSED FROM "PUBLIC WORKS"

One of the vital principles relating to the economical generation of steam is that of appropriating every available unit of heat.

Seventeen boiler tests made by Messrs. Donkin & Kennedy show that the waste heat passing to the chimney, where no economizers are used, ranges from 9.4% to 31.8%, or an average of 20.3% of the total heat of combustion.

Furnace temperatures range from 2,500° to 3,000° F., depending upon the amount of air admitted. The gases reach the boiler heating surfaces at 2,000° F., and are rapidly cooled while passing over them. In practice, boiler heating surfaces reduce the gases to temperatures varying between 530° and 670° F., or an average of 600° F.

Assuming the coal to yield 13,500 heat units per pound, and that 24 lbs. of air are admitted for each pound consumed, 25 lbs. of gas will result. Each degree of temperature through which the 25 lbs. of gas are raised requires about 5.7 heat units. The number of heat units in flue gases having 600° F., the atmospheric temperature being 40° F., will be (600—40) × 5.7 = 3,192, or 23% of the total heat produced.

It is manifest that in this direction ample opportunity is provided for increasing boiler efficiency.

This loss can be diminished, either by increasing the boiler heating surface or by resorting to stage heating, by introducing one or more separate heaters. Boiler heating surface is too expensive to extend further than compatible with reducing the gases to 500° or 600° F., beyond which the expense, together with the losses due to radiation and conduction, exceed the saving effected. This will be readily realized from the fact that while heat transference through boiler plates is directly proportional to the difference in temperature between the water within and the gases without the boiler, the heat losses from the boiler are also proportioned to the extent of its surface. The transference of heat to the water diminishes with the falling temperature in the gases, and where there is only a slight difference between the temperature of the water within and the gases without the boiler, as in high pressures, the limit is soon reached, and inefficiency follows.

By receiving feed water at ebullition temperature the boiler exercises its proper function of a steam generator, instead of being compelled to fulfil the double part of water-heater and steam-raiser. The gain in such circumstances is due to the greatly accelerated passage of heat when evaporating: about two times as much, indeed, as when only heating.

No one willingly feeds a boiler with cold water if exhaust steam or flue gases, or both, are available. Apart from its economical aspect, cold feeding produces undesirable strains upon the plates or tubes where contact takes place.

Feed-heating by exhaust steam, while good

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as far as it goes, soon reaches its limit, since, to prevent back pressure, the steam must be exhausted into the atmosphere, and, in the open air, water and steam can only be heated to 212° F. In practice, feed water from exhaust steam heaters seldom exceeds 200° F. Exhaust steam may also be used more profitably where general heating is necessary, or where certain manufacturing processes render it utilizable. To heat feed water by this means alone is to participate in part only, and a small part, of the available opportunity to economize, since the 23% of the total heat in the coal contained in the flue gases passing to the chimney remains unreclaimed.

The recovery of this heat by suitable apparatus, and its application to useful purposes is clear gain, since the energy is otherwise wasted in the open air.

Where only non-condensing engines are permissible, and no other use can be found for the exhaust steam, a preliminary, or first stage, heater may be employed, water being delivered from it to the economizer, or second-stage heater, at 200° F., from which, in turn, water at 300° or 330° F. may be supplied to the boilers, the number of pipes in the economizer being proportionately less than if required alone to raise water from atmospheric temperature.

As described already, the number of heat units in 25 lbs. of flue gas at 600° F. obtained from the combustion of 1 lb. of coal is 3,192. When reduced to 300° F., the temperature consistent with normal chimney draft, the heat units given up will be (3,192 ÷ 2 =) 1,596 per pound of coal burned, or (1,596 ÷ 13,500 =) 12% of the total heat developed by the combustion of 1 lb. of coal.

If water enters at atmospheric temperature, the whole of the heat extracted from the flue gases will be appropriated by it; but if taken from the hot well, or heated by exhaust steam, the heat appropriated will be less than is recoverable from the flue gases.

Assuming the boiler evaporation to be 8 lbs. of water per pound of coal burned, the heat units required to raise water from 40° F. or atmospheric temperature to 280° F. will be (241) 8 = 1,928; but to raise from 100° to 280° F., the heat units required will only be (181) 8 = 1,448.

Boilers having 68% efficiency, and fired with coal containing 13,500 heat units, will transfer (13,500) 0.68 = 9,180 heat units to the water for each pound of coal consumed. The combined efficiency of such a boiler, and the economizer described, will be 68 + 12 = 80%, and if all the heat extracted from the gases is appropriated by the feed water, the steaming capacity of the boiler will be increased by (1,596 ÷ 8,040 =) 17.38%.

Feeding with water at atmospheric temperature reduces the flue gases to a very low degree, and may affect the normal chimney draft. It also involves risk of sweating and corrosion on the economizer pipes. By feeding with water at, say, 90° F., both difficulties are avoided. Where this is impossible, special provision is made on the economizer whereby the sweating or corrosion is located to two or three sections at the feed-water inlet end of the economizer, the remaining part being protected by the preliminary heating thus affected.

To raise the 25 lbs. of flue gas produced by the combustion on 1 lb. of coal under the conditions described to the top of a chimney 100 ft. high, assuming a factor of 1.25 for friction losses (25 × 100 × 1.25 =) 3,125 lbs. are required; 2,500 lbs. towards this is performed by the descending column of cold air outside the chimney, leaving (3,125 — 2,500 =) 625 ft.-lbs. unprovided. If this work is done mechanically by a steam boiler, direct geared engine and fan, having 4% resultant efficiency, inclusive of friction losses in the combined apparatus, the foot-pounds developed as heat by coal combustion will be (625 ÷ 0.04 =) 15,625, which, since 778 ft.-lbs. represent 1 heat unit, equal (15,625 ÷ 778 =) 20.1 heat units per pound of coal consumed, or (20 ÷ 1,596 =) 1.25% of the heat units appropriated by the economizer in reducing the flue gases from 600° to 300° F.

Records taken show the importance of preventing the accumulation of soot, which is a notorious non-conductor of heat, upon the pipes. An economizer worked continuously for seven weeks, with scraper gearing at rest, accumulated a coating of soot and ashes ½ in. thick. A week's record of feed-water temperature taken while in this condition, when compared with records taken from the same economizer with scrapers continuously working, showed a drop of 65° F. in the temperature of the water delivered. A further experiment made, whereby the same economizer, after the cleaning of the pipe surface, worked continuously for one week with the scraper gearing again at rest, showed 53° F. drop in the temperature of the water delivered. The adverse influence of soot, and the necessity for cleaning the pipe surface by frequent, if not

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continuous, use of scrapers, is clearly shown. The advantages attending the installing of an economizer may be enumerated as follows: (1) Heating the feed water for steam boilers to higher temperatures than is obtainable by other means; (2) increasing the efficiency of the boilers by considerable additions to heating surfaces; (3) utilizing heat in a practical way from flue gases otherwise escaping to the open air in waste; (4) clarifying the feed water by slow circulation and high temperature, depositing the sediment into the bottom heaters, from which it can be readily blown out; (5) providing a large reserve supply of feed water at evaporating temperature for delivery to the boilers; (6) prolonging the life of the boiler by providing it with hot feed water, thus preventing the expansion and contraction incidental to feeding with cold water; and (7) saving of 10 to 20% in fuel.

THE WEATHERING OF COAL*

By S. W. PARR and N. D. HAMILTON

Judging from the opinions of practical engineers and scientists, the present methods of coal storage without doubt often result in much loss from fires of spontaneous origin and more or less loss by a deterioration in fuel value of the coal itself. The leading factors entering into the cause of these losses have been pointed out as being: (1) the kind of coal as to its volatile combustible contents; (2) the presence of occluded inflammable gases in the coal both before and after mining; (3) the presence of pyrites or other sulphur compounds; (4) the size of the coal; (5) the presence of moisture; (6) the temperature; and (7) the accessibility of oxygen to the coal.

From the evidence at hand there seems to be very little doubt that the coals of the lignitic, bituminous and semi-bituminous character with their relatively high amounts of volatile combustible matter have a much greater tendency to weather than the anthracites where the volatile matter is low. There is considerable evidence that methane and other inflammable gases formed during the decomposition of vegetable matter which produces the coal are contained in the crevices of the coal as it lies in the earth, and are liberated both during and after mining. This exudation of inflammable gaseous matter may be a prime element in mine explosions, and its continuance after storage may be a large factor in the deterioration processes.

Opinions differ as to just what part sulphur compounds, the most important of which is pyrites, play in the deterioration of coal. Some assign the leading part in cases of spontaneous ignition to pyrites, while others think that its action in this connection is of only minor importance and that absorbed oxygen has most to do with this phenomenon. Observations on the effect of the air upon pyrites, however, seem to have pretty generally established the notion that pyritic oxidation tends to raise the temperature of the coal as well as to increase the tendency of the coal to break up, and that this oxidizing action is quite appreciably increased by the presence of moisture.

That slack is much more liable to spontaneous ignition and the deteriorating influence of weathering agents seems to be the general opinion. Having more surface the finer particles absorb oxygen much more rapidly and this rapidity of absorption causes an increase in temperature which in turn produces better conditions for absorption and chemical action between the carbon, hydrogen and pyrites of the coal and the absorbed oxygen. It would seem that the finer coal would hold the moisture longer, resulting in a greater use being made of its catalytic qualities.

It is thought by some authorities that the only part moisture plays in the deterioration of coal is to materially assist the pyritic oxidation or by alternate freezing and thawing in the crevices of the coal to expose more surface to weathering agents. There are many, however, who believe that aside from increasing the oxidation of pyrites, water has to do with other chemical activities, which result in the decomposition of the coal. These believe that oxidation of the carbon and hydrogen of the coal is hastened by the action of the water

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present. This latter view seems to be based on the fact that moisture has seemingly, in some instances, greatly increased the deterioration of practically non-pyritic coal.

That an increase of temperature has much to do with increasing the activity of the other deteriorating agents is the general belief. This rise of temperature, whether coming from outside sources or physical or chemical action within the coal, tends to accelerate the absorption of oxygen and thereby increases the oxidation going on and also evaporates the gases which may still be occluded in the coal. Thus heat assists in decreasing the fuel value of the coal and at the same time increases its liability to ignition. That the exclusion of oxygen from coal will decrease its loss in heating value is a growing belief.

From the evidence at hand, therefore, it would seem that not only do observers differ widely as to the causes and extent of weathering, but no very exact study of the problem has been made in all of its phases on which could be based very much either of theory or fact concerning the deterioration of coal in storage.

EXPERIMENTAL WORK.

In the present studies no attempt has been made to include all types of bituminous coals, but only those of the Illinois field.

There were nine initial samples taken of approximately 100 pounds, respectively. The coal was of small lump or nut size and each sample was subdivided in order to subject the same kind of coal to various conditions. These conditions were to be continued through nine months, and in general were:

(a) Outdoor exposure; (b) exposure to a dry atmosphere at a somewhat elevated temperature, ranging between 85° and 120° F.; (c) under the same conditions as (b), so far as temperature was concerned, but to be drenched with water two or three times per week; (d) submerged in ordinary water at a temperature approximately 70°.

The periods for examination were divided as nearly as the work would permit into

1. The initial analysis of the fresh coal.
2. After exposure for five months.
3. After exposure for seven months.
4. After exposure for nine months.

SUMMARY OF RESULTS OBTAINED.

(a) Submerged coal does not lose appreciably in heat value.

(b) Outdoor exposure results in a loss of heating value varying from 2 to 10 per cent.

(c) Dry storage has no advantage over storage in the open, except with high sulphur coals, where the disintegrating effect of sulphur in the process of oxidation facilitates the escape of hydrocarbons or the oxidation of the same.

(d) In most cases the losses in storage appear to be practically complete at the end of five months. From the seventh to the ninth month, the loss is inappreciable.

(e) The results obtained in small samples are to be considered as an index of the changes affecting large masses in kind rather than in degree, but since the losses here shown are not beyond what seems to conform in a general way to the experience of users of coal from large storage heaps, it may not be without value as an indication of weathering effects in actual practice.

AEROPLANE DESIGN

FROM "ENGINEERING"

In the course of the discussion on a paper on "Aerial Navigation," recently read before the Junior Institution of Engineers, Captain Ferber, of the French Military School of Aeronautics, gave certain formulas as being adequate for the design of any type of aeroplane. The resistance of the air could be obtained from the equation

$$P = 2\ K\ S\ V^2 \sin \theta,$$

where θ was the angle of impact, S the area of the surface in square metres, V the velocity in metres per second, and K a constant. P would then be the pressure in kilograms. As θ was difficult to measure, the expression

$$P = K^1\ S\ V^2$$

might be used, and would be near enough for practical purposes if K^1 were taken as = 0.06. It will be noticed, as Captain Ferber pointed out, that this gave results about eight times more favorable than those in the generally accepted table of Herbert Spencer; and thus, contrary to general belief, an aeroplane could be made to fly fairly easily.

It seems generally accepted that, with aero-

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planes as at present constructed, the total area in square feet should be about half the total weight of machine and load in pounds; or, in other words, that 2 lbs. may be supported per square foot of area. This ratio was given by Mr. Herbert Chatley, in his paper above referred to, and he illustrated it by quoting examples of successful machines. Farman's machine, if the figures published are correct, has a net weight of 1,100 lbs., and an area of about 690 sq. ft., so that, with a man on board, the ratio of weight to area would be about 1.6. The comparison of these proportions with those that obtain in the case of flying creatures is probably of more interest than practical value, as the proportional wing area of the sparrow is twice that of the pigeon, while the pigeon has, weight for weight, twice that of the stork, and so on. M. de Lucy has given the proportions for various insects and birds, the heaviest of which is the strong-flying Australian crane. This bird has the least wing area in proportion to weight of all those measured, the wing surface supporting about 2.4 lbs. per sq. ft.

The tractive force F to maintain horizontal flight might vary from one-third to one-fifth of the weight of the machine; a quarter was a fair value; but if a third was taken, there would be no doubt of the rising of the machine from the ground. Assuming a propulsive efficiency of 50%, and a tractive force of one-quarter the weight, the horse-power then works out at

$$HP. = P V/150.$$

For the design of aerial screws the following formulas were given by Captain Ferber:—

$$F = a\ h\ r\ n^2\ d^4$$

$$L = (B\ h^2\ r + B^1)\ n^2\ d^5,$$

where F is the pressure in kilograms, L the work in kilogram-metres, n the revolutions per second, d the diameter in metres, h the ratio of pitch to diameter, r the slip, and a, B and B^1 coefficients depending upon the screw employed. In screws used by Captain Ferber for aeroplane-driving the coefficients had the following values: a = 0.033, B = 0.027, B^1 = 0.003.

Major B. Baden-Powell made the striking statement that a plane surface, set at what may be called a negative angle of lift, had, nevertheless, been found to rise when pushed forward. If this is confirmed—and the Major showed an experiment which seemed, to some extent, to substantiate it—it is another example of how very little is really known about the action of aeroplanes. There is an enormous amount of practical experimenting to be carried out before we are sure that we are working on the right lines of design; as, unfortunately, the mathematical theories so far propounded are absolutely unreliable, owing to want of sufficient and accurate data.

THE HORSE-POWER MEASUREMENT OF MARINE STEAM TURBINES*

By J. HAMILTON GIBSON

When a revolving shaft transmits power it always twists slightly throughout its length. In other words, the end at which the power is applied moves slightly in advance of the end where the work is done, the amount of twist varying directly as its length, directly as the moment of the load applied, inversely as the rigidity of the material, and inversely as the fourth power of its diameter, the formula reading:

$$\theta = \frac{10.2\ TL}{CD^4}$$

where θ is the angular displacement in radians, T = twisting moment in inch-pounds, L = length of shaft in inches, C = the modulus of rigidity, and D = diameter of shaft in inches. The law holds good absolutely for all shafts which are not stressed beyond the elastic limit. As shafts are usually designed with a large factor of safety, it follows that the amount of twist, or the "torque," as we prefer to call it, is very small. In propeller shafting, for instance, the torque is rarely more than 1° for 10 ft. of length, so that for a 12-in. shaft the circumferential displacement is only about ⅛ in. at full power.

*From a paper read recently before the Northeast Coast Institution of Engineers and Shipbuilders.

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Various methods and numerous instruments have been devised to enable an observer to read off the torque of revolving shafting, and such instruments are rightly termed "torsion-metres," or, if self-registering, "torsion-indicators."

The rapidly-growing adoption of steam turbines for ship-propulsion has created a demand for some ready means of ascertaining their horse-power, and as the steam-engine indicator is not suitable for this purpose, we are thrown back on a torsion-metre as the only known method by which such information can be obtained. The power of a steam-turbine may be estimated approximately by calculating the amount of water passed by the feed-pumps, or by measuring the number of heat units that pass through the turbines in a given time; but a coefficient of efficiency must be first determined, and no account is taken of the revolutions in such estimates. As, however, "revolutions" is the very essence of power in dealing with the question of ship-propulsion, that would be a very unsatisfactory method of reporting the power from a shipowner's point of view.

Now, a turbine, unlike a reciprocating engine, passes almost as much steam when standing as when revolving at full speed; and it is necessary, therefore, in fixing the responsibility as between the boiler and the turbine, to know what power the turbine is transmitting to the propeller under varying conditions. The power thus ascertained is called the "shaft horse-power," in contra-distinction to the term "indicated horse-power," which has come to be applied exclusively to the results obtained by "indicating" the mean pressures in the cylinders of a reciprocating engine. In this connection, "brake horse-power" and "shaft horse-power" are, of course, identical.

A small propeller working deeply immersed in smooth water is a fairly uniform brake, and the turning moment of a steam turbine is also very uniform. Consequently there is little, if any, fluctuation of the torsional stresses in the propeller shafting. If, then, we can ascertain the torque at only one point in each revolution, it may be assumed that, knowing the revolutions, we have all the information required to calculate the work done. It is very different, however, in the case of reciprocating engines. The turning moment is anything but uniform; there are several points of maximum and minimum torque in each revolution; in fact, it is not an unknown experience to find that at one or more points in each revolution the torque is negative—that is, the propeller, acting as a fly-wheel, overruns the engine, and actually pulls the engine round after it. In all cases of reciprocating engines, therefore, it becomes necessary to read off the torque at several points in the revolution; the more points the better. The mean torque is then taken in making calculations of power. For a clear appreciation of the problem of torque measurement, it is expedient to keep the foregoing facts well in mind, and principally to remember that we are dealing with extremely minute angles, for it is no exaggeration to say that an error of a hair's breadth may mean a difference of several hundred horse-power in the result.

Before applying any form of torsion meter to a shaft, we must know the "modulus of rigidity" of the latter—that is, how much of it will twist with a given static load applied at the end of a lever of known length. This can only be done satisfactorily in the workshop, preferably on a long rigid lathe bed. One end of the shaft is securely fixed, and a twisting moment applied at the other end. To eliminate the effect of friction in the supporting bearing at the free end it is advisable to use two levers, one at either side, and the loads are then preferably applied by means of graduated spring balances. Two pointers independent of the local levers are secured to the shaft, as far apart as practicable, and the difference in the angular movement of these two pointers gives the true twist for that length of shaft. If the pointers are made 57.3 ins. long from the shaft axis, their ends will describe 1 in. of arc for 1 degree of twist, and a decimally-divided straight edge will then measure the twist to within 1/100 deg., which is quite near enough for all practical purposes, and we can proceed to calculate the modulus of rigidity from the formula.

Observe that a propeller shaft is subject to two distinct stresses. Not only is it twisted as between the engine and the propeller, it is also compressed longitudinally by the propeller thrust, the compressive stress being sometimes as much as 20% of the shear stress at the surface of the shaft, produced by torsion alone. This compression augments the torque by an appreciable amount, which has been actually measured in numerous experiments, and may be taken roughly as 3% for hollow shafts and 1% for shafts which are solid. It might be considered sufficient to calibrate only one shaft in

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a multiple-screw vessel; but it is found that similar shafts, with identical tensile and elongation tests, have different moduli of rigidity, probably due to their varying elastic limits and some slight difference of homogeneity in the material. The only way, therefore, to ensure accuracy is to calibrate each shaft separately and to build up a power diagram for each.

Another point to bear in mind is that a working propeller-shaft is "alive," and this condition must be imitated as far as possible during calibration, by jarring the shaft with repeated blows of a mallet, so as to keep the mass in a state of molecular vibration. Otherwise the phenomenon of mechanical hysteresis, so marked in some static experiments, will obtrude itself and vitiate the results.

Having established the true modulus of rigidity for each shaft, we may proceed to build up our power diagrams based on the formula $H = \Theta D^4 N/L$, where H = shaft horse-power, Θ = torque in degrees, D = diameter of shaft in inches, N = number of revolutions per minute, C = constant varying with the modulus of rigidity, and L = length of shafting in inches. In this formula we have all the elements for obtaining the shaft horse-power, and it only remains to ascertain the number of degrees of torque by means of a reliable and accurate torsion-meter.

NOTES ON STEAM LOCOMOTIVE DESIGN*

FROM THE "STREET RAILWAY JOURNAL"

The first consideration in the design of a locomotive is the allowable wheel pressure on the rail, the weight at the driving wheels being determined by that. The number of driving wheels is generally limited to four pairs in freight and three pairs in passenger engines, the length of the rigid driving wheel base being limited to 16 or 17 ft., on account of curves. A two-wheel pony truck is considered most suitable for freight engines, while a four-wheel truck is most generally used in passenger service, but for the varying conditions of service naturally several types of engine are necessary. The different types are distinguished from each other by names and figures. The first figures generally representing the grouping of the wheels. The first engine signifies the number of the wheels on first truck; second figure, number of drivers, and third figure, number of wheels in trailing truck. Thus we have the light passenger engine classified as 4-4-0; the medium size, or Atlantic type, 4-4-2; the heavy passenger, or Pacific type, 4-6-2, and the 10-wheel type, 4-6-0, the latter as well as the Mogul type, 2-6-0, and the Prairie type, 2-6-2, being most suitable for mixed or fast freight service. For regular freight service, the consolidation, 2-8-0, has practically become standard.

The required cylinder power is figured on the basis of tractive weight, or weight of driving wheels on the rail. The boiler pressure is always predetermined, and the diameter of drivers is about equal in inches to the speed the engine is expected to run in miles per hour. The stroke is selected so as to give the required maximum train speed to a moderate piston speed. Two of the most important factors in a successful locomotive are the heating surface and grate area. The method of determining those factors which has generally been adopted and gives satisfactory results is to make the heating surface in square feet not less than 450 times the volume of one of the cylinders in cubic feet for passenger engines and 400 for freight, the grate area being about 1-70 of this amount.

*Report of an address delivered before the Schenectady Section of the A. I. E. E. by Mr. C. J. Mellin, Consulting Engineer of the American Locomotive Co.

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The relation of the complete tunnel system to New York City may be followed out readily by reference to the map, Fig. 2.

The southerly pair of tunnels, or lower tunnels, taps New York City about half a mile north of the Battery, the southerly end of Manhattan Island. A pair of 22-story office buildings has been erected over the terminal loop, on the westerly side of Church St., covering the two blocks between Cortlandt St. and Fulton St. This is within five minutes' walk of the Sub-Treasury, the center of the financial district. The New York Rapid Transit Subway, on Broadway, one block east of the Church St. terminal, will be brought into direct connection with it by an underground foot passage along Dey St., entering the south end of the Fulton St. station of the Subway. From the Church St. terminal westward to the river there will be four tracks, two under Fulton St. and two under Cortlandt St. These connect with two single-track tunnels which cross the river, converging in a station lying directly under the Jersey City terminal of the Pennsylvania R. R. Thence the line continues double-tracked in a west and a north branch, each double track. The former rises to the surface and enters upon the main line of the Pennsylvania R. R. just east of the cut through Bergen Hill. The north branch extends along Washington St., Jersey City, in tunnel, about 1¼ miles north, crossing under the tracks of the Erie Ry., to a junction with the west approach of the upper tunnels. At both of the junctions mentioned, the opposing tracks separate to two superimposed levels, thereby avoiding crossings at grade. From the upper junction the line continues north, crossing under a river slip and then under the tracks of the Delaware, Lackawanna & Western Ry. Just north of the tracks it turns east to a large underground terminal station alongside the Lackawanna trainshed and ferry-house.

The historic upper tunnels extend from the junction eastward under Fifteenth St., Jersey City, with a maximum down grade of 5%, under the river, to a depth of about 90 ft. below low water, then rising with a 3% maximum grade to the old caisson at the foot of Morton St., New York. Excluding the old brick portion of the subaqueous tunnels, all this work is iron-lined tunnel, the two tracks being in separate circular tunnels, except that the Hoboken junction is of concrete, constructed in a caisson of reinforced concrete sunk from the surface.

The New York approach rises rather steeply eastward along Morton St. to Greenwich St., thence north on Greenwich St. two blocks to Christopher, and turns east on Christopher St. At Christopher and Greenwich Sts. is the first station.

The line extends east along Christopher St., still as a pair of circular iron-lined tunnels driven by shield, to Sixth Ave., where Sixth Ave., Christopher St., Ninth St. and Greenwich Ave. intersect. Here the Greenwich Ave. station is located. The grade along Christopher St. is flat, being determined by the requirement of the old Rapid Transit Commission that at Hudson St. (a block east of Greenwich St.) and at Greenwich Ave. the tunnels be kept so low as to give at least 20 ft. clear below the street surface for future rapid-transit subway construction.

At Sixth Ave. the line turns north, and also branches eastward into Ninth St. The main line extends up Sixth Ave. to 33d St. The shield-driven tunnels continue to Twelfth St., rising steadily. Here begins a reinforced-concrete subway type of construction and continues the remainder of the distance to the 33d St. terminal.

The tunnels under the river have variable spacing, averaging about 30 ft. c. to c. for the upper tunnels. The land portions of the iron-lined work have a spacing of 18 ft. to 25 ft., depending on local conditions.

The iron-lined tunnels generally have an outer diameter of 16 ft. 7 ins. and an inner diameter of 15 ft. 3 ins. inside the iron (8-in. flanges). The upper river tunnels have different diameters, as already noted. On curves the standard dimension is changed to 16 ft. 6 ins. outside and 15 ft. 4 ins. inside, with 7-in. flanges. The sharpest curves, at Morton St. and at Greenwich Ave., are of 150-ft. radius on the center line of the inner facing of concrete over the invert and up to the center line (Fig. 3). The cable ducts are embedded in concrete benches on either side.

The reinforced-concrete section consists of two rectangular single-track compartments separated by a 15-in. dividing wall. The dimensions of each compartment are 13 ft. wide by 14 ft. 6 ins. high inside; the inner line of the roof is arched, and the height is that at center of compartment. The cable ducts extend along the outer wall, and the track therefore is placed 6 ins. inward of the center line, making the spacing of the two tracks 13 ft. 3 ins. c. to c. Where the columns of the Sixth Ave. ele-

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well-known straps, but also with steel uprights set at intervals along the front edges of the seat rows. The fare in the tunnels is 5 cts. between any two points, against a fare of 8 cts. when using surface cars and ferry.

The complete separation of the two tunnels, maintained by the dividing wall in the reinforced-concrete section and interrupted only at Christopher St. station, the Greenwich Ave. station, and two cross-overs located just west of the latter, and at 19th St., is relied upon to take care of all needs in the way of ventilation. The train movement in either compartment will act, like a series of pistons moving in the same direction, to produce a steady forward current of air. Additional ventilation will be furnished by fans at several points of the system forcing fresh air into the tunnels and sweeping the heated and vitiated air out of the station openings.

The Hudson & Manhattan R. R. Co., which operates the system, is under the presidency of Mr. William G. McAdoo. Mr. Walter G. Oakman is President of the Hudson Companies. Mr. Pliny Fisk and Mr. Wm. M. Barnum of the banking houses of Harvey Fisk & Sons, have been closely connected with the financing which made the work possible. The engineering and construction work was done by Mr. Charles M. Jacobs, M. Am. Soc. C. E., Chief Engineer, and Mr. J. Vipond Davies, M. Am. Soc. C. E., Deputy Chief Engineer. The total cost of the tunnel system and its equipment will reach $70,000,000.

SMALL WATER SUPPLIES

THE GENERAL DESIGN OF A WATER-WORKS SYSTEM

By H. C. H. SHENTON, M. S. E.

CONDENSED FROM "PUBLIC WORKS"

The object of the present article is to consider how, having obtained a supply of water, it may be best conducted to the places where it is required.

There are a few general facts bearing upon the question which may be stated briefly at the outset:

(1) If a gravitation scheme can be arranged it is the best and cheapest system. In the case of a gravitation scheme the first cost of the work represents, practically speaking, the whole outlay, whereas with a pumping scheme the cost of working must be added, and this represents the interest of a large capital.

(2) If the source is practically inexhaustible, a large storage reservoir will not be needed. The spring, well or stream from which the water is drawn becomes the storage reservoir in that case.

(3) If the supply comes from an intermittent source, a very large storage reservoir may be needed.

(4) If the supply is continuous but small, a storage reservoir will be needed sufficient to hold all that comes, letting it flow out into the mains when required at a quicker rate than that at which it comes into the reservoir.

(5) Filters may be required or not, according to the nature of the water.

(6) Softening plant may be needed for hard water.

(7) Certain waters must not be run through lead pipes.

(8) Storage reservoirs are those used to retain a large quantity of water, which may flow in slowly or intermittently from springs, gathering grounds, streams or pumping mains.

(9) Service reservoirs are those used to hold say, two or three days' supply for a particular purpose—e.g., to allow for irregularities of pumping, or to provide for a sudden large demand for fire purposes. Separate service reservoirs may be needed to reduce the pressure in the mains.

(10) Sometimes reliance is placed on pumps only, the pumps being made to deliver into a small tank on a water-tower, or into mains over a standpipe. It will generally be found advantageous, if the pumps can be made to deliver into a reservoir of good size.

(11) It may be possible to supply the lower parts of a district by gravitation, while the supply for places at higher levels may have to be pumped. Small service reservoirs may be

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placed on the highest hills and other service reservoirs on lower sites, each having their separate systems of mains. The judicious laying out of the district in such zones will have a most important effect upon economical working.

(12) The laying down of mains and services, their general arrangement, the proper sizes of pipes, and the placing of valves, meters and wash-outs, and other details of the work, is another section of the subject which is of the greatest importance.

It is not too much to say that each of the twelve headings given above would form an excellent subject for a separate article or series of articles, and to these can be added a thirteenth—viz., the important subject of pumping or lifting the water.

The author is reluctantly obliged to omit the subject of pumps and pumping from this article, seeing that space would not allow him to do more than touch it in the most superficial manner.

COLLECTION OF WATER.

Water issuing at ground level in the form of springs is generally intercepted by means of gathering drains. These drains are generally made of unglazed stoneware pipes, with open joints which run to small catchpits. Sometimes canvas or similar material is lapped round the butt joints of the pipes to exclude sand, all water thus filtering through the canvas or through the porous pipes.

The object of these drains is to catch the water which is passing through the ground near the surface; as for instance, in case a number of small springs exist at the edge of a gravel patch it is clear that some such gathering drain is required.

Where water issues in large volume at one spot, as from a fissure in the chalk or limestone, it may be at once caught in a pool, pit or small reservoir.

The catch-water drains or channels are carried to small catchpits. These are generally built of concrete or masonry, and should be made water-tight by rendering with cement or by other means. They should have large iron covers to allow for cleaning, and also so that field-mice, insects, etc., cannot get into the pit. It will be found better to use iron covers than wooden, since wooden covers will eventually rot and allow things to fall into the pit. For the same reason it is well to carry the coping a few inches above the ground level.

The number and size of these pits will depend upon the number and size of the springs. The bottom of the pits should be two or three feet below the outlet and inlet pipes, so that solid matter may be retained. They can be cleaned as often as necessary with spades and buckets.

It is usually best to carry iron pipes from these catchpits to the storage reservoir, but stoneware pipes with cement joints are sometimes used. With iron pipes valves should be fixed at the top and at the end of each main, so that they may be under control either at the pits or at the reservoir. The collecting main runs from each catchpit to the storage reservoir, and there it should enter a second grit chamber, and it is also well to let the water run into the reservoir through a submerged arch or dipping pipe, so that leaves or other floating matters present may be kept out of the reservoir. There should be a depth of two or three feet in the grit chamber to intercept sand. There should also be an overflow weir in case of an excessive flow.

Water running from an open channel or stream into a reservoir should pass through one or more grit pits or the reservoir will become silted up.

In the case of a lake or of a river the water of which is used for drinking purposes for small supplies, the river or lake may be considered the storage reservoir; for very large supplies the case is different. Where the water does not exist at ground level it must be gathered by means of wells or adits.

In designing a waterworks intake of any kind, and especially that from a river or lake, the object should be to draw off the purest water and to avoid taking up floating matters or silt. It may be necessary to carry the intake pipe out into the lake or river some distance below water, or to build a special inlet tower as in the case of a large storage reservoir.

Water falling over large areas of moorland or mountain is collected in storage reservoirs into which the water flows through its natural channels. In small schemes special gathering grounds are sometimes specially prepared and even paved on the hillsides, so that the water intercepted may be quite clear.

STORAGE RESERVOIRS.

Storage reservoirs are of several kinds, varying from vast lakes formed by damming the end of a valley and thus intercepting the rainfall of a certain watershed, to the small covered underground rain-water tank, which will

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hold about one-third of the expected annual rainfall on the roof of a house.

Where a natural valley exists at a proper level, taking the drainage from the hills above, it is often a simple matter to select a point where the valley is narrow and the hills steep, and by constructing a comparatively small dam to impound a large quantity of water. The engineer will prefer to build this dam of masonry, concrete, or brickwork if possible, but from motives of economy earthwork dams are often made.

The storage reservoir must hold water for the supply of its district during the severest drought. There are many reservoirs of the type mentioned into which no water comes during dry weather, and it will then be necessary to see that the quantity impounded during the rains is sufficient to keep up a supply of water for about six months.

Hawksley's rule for the storage of water is:

$$= \frac{1{,}000}{\sqrt{\text{inches or rainfall per annum}}}$$

= the number of days' supply the reservoir should contain.

If the rainfall is taken at 25 in. per annum the calculation will be as follows:

$$\frac{1{,}000}{\sqrt{25}} = \frac{1{,}000}{5} = 200 \text{ days' supply.}$$

Let us assume that the place to be supplied had a population of 2,000 persons, and that an allowance of 30 gallons per head per diem was required. The storage reservoir should hold $2{,}000 \times 30 \times 200 = 12{,}000{,}000$ gallons.

Such large storage reservoirs only occasionally form any part of a small system. When they are constructed the dam should be made long and shallow rather than short and deep, as the cost will be less. The reservoir should not be too shallow, for weeds, vegetable matter, etc., grow luxuriantly in water less than 5 ft. deep. The ground must be watertight; water retained by the dam will soak away and there will be great risk of the dam itself being wrecked. The dam must be so arranged that water cannot get under it. The natural ground, when the top-soil and vegetable growth has been cleared away, will be a floor sufficient for all practical purposes. It must never be assumed that because a reservoir is large, or because there is an abundant supply of water running into it, that a leak is unimportant. A very small leak may some day become very large and cause extraordinary damage.

If a masonry dam is built it must be carried down to form a watertight joint with the impervious earth or rock at its base, and not only that, but its ends must also be joined to the impervious stratum in the hillsides, so that no water can leak round it. The same principle must be borne in mind in constructing an earthwork dam. Such a dam is frequently made with a puddle-clay trench in the middle. This puddle clay has to be carried down to the impervious stratum below, as shown in the figure. Owing to the cost, masonry dams are seldom made, whereas earthwork dams are common. Such dams generally have an inside slope of 2 to 1 and an outside slope of 2½ to 1, the top of the embankment being about 6 ft. wide. For small dams of this kind it will be found best to line the inside face with clay puddle or other watertight material. The practice of putting in a puddle trench in the middle of an embankment which is not impervious is wrong in principle, since half the embankment is doing no work, and may, if saturated with water, tend to overturn the remaining half. Earth saturated with water for a long period tends to become fluid, and in that case only the part of the dam on the further side of the puddle clay, or other core, would support the water pressure.

The objection to lining the inside slope of reservoirs with puddled clay is that it is apt to become disintegrated by the action of the weather. This can be prevented by protecting the surface with suitable paving.

In the construction of reservoirs or other watertight structures of any kind, one absolutely watertight lining is infinitely better than a dozen linings put one over the other, each of which is "practically watertight"; that is to say, which lets a very little water by. As fast as the water is stopped at one place it comes in at another, and this making good of quite little leaks goes on indefinitely and until the tank is lined with the very greatest care, so that not a drop of water can enter, it will never be sound.

The overflow of a reservoir of this kind must be very carefully arranged, since any flow over the top of the earthwork dam would be fatal. The earth would be cut away and the dam would disappear. In providing for the overflow it is customary to do one of three things: (a) To construct a masonry section of the dam and to conduct the overflow down this with the greatest care, so that there may be no possibility of injury to the embankment or to the

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foundations of the masonry section; (b) to make an overflow pipe or shaft in the reservoir, and to conduct water from this in a tunnel, arranged, if possible, well away from the dam, and (c) to build the overflow at the side of the reservoir, and to conduct the water away in a tunnel, or other conduit, avoiding the dam altogether.

Outlet pipes should not leave the reservoir through the earthwork dam, as they would constitute a source of weakness. The best method of avoiding this will depend upon circumstances. For instance, the pipes can be laid in a tunnel below the impervious stratum forming the floor of the reservoir, and can enter the reservoir through a tower of masonry, or cast-iron, which makes a watertight joint with the floor so that no leakage can possibly take place under it.

Where levels permit service reservoirs are generally made half in and half out of the ground, in order that the thickness of the wall may be reduced, for a wall supported by a backing of solid earth or rock may be made much thinner than a wall entirely above ground level, backed by earth only. In case the wall of such a reservoir is made in rock, the lower part of the wall can be very thin. In a similar reservoir wall, the lower part of which is constructed in fairly solid ground, the lower wall must be made of sufficient thickness to retain the solid ground, but no account need be taken of the water pressure. In this case the wall can be made thinner than under ordinary circumstances, since its strength is increased by the weight of the wall above. In the case of the same reservoir wall constructed in soft earth or made ground, the solid earth existing only at the lowest level, the wall is made to take both the thrust of the earth and the thrust of the water, for the made ground or soft earth cannot be trusted to support the wall against the pressure. The portion of the wall which comes above ground level is constructed as an ordinary dam, and the reason for making it of such dimensions is that it may be able to withstand the water pressure without any earth backing, because the embankment is at its best only made ground, and should not be trusted to support a wall against the horizontal thrust of the water.

If a wall is constructed with its back against earth which is not hard, or if it has fallen in so that gaps occur behind the walls, it should be strengthened, the gaps being filled in with coarse concrete or other hard material. Moreover, the back of the wall should be vertical, or there will be a backing of made earth which will not support it properly against the water thrust.

When the reservoirs are roofed, the roof is generally made of concrete or brickwork arches, or concrete laid flat, and supported on steel joists. In constructing a covered service reservoir it will be useful to bear in mind the following facts: The excavation should be carried down to the full depth and for the full width of the foundation of both floor and walls, and the concrete should be laid over this excavated floor to the full width of the excavation, so that the walls may stand upon a solid platform. Building the walls first and the floor afterwards is likely to produce unequal settlements. The principle will be fully grasped if one remembers that in Lincolnshire, where the foundations are soft, large chimney stacks, 200 ft. or 300 ft. high, are frequently supported upon a thick platform of concrete; that is to say, they are practically founded on a raft of concrete which floats on soft ground into which the chimney stack would sink if its base were of smaller area.

If the reservoir walls are built of concrete, it may or may not be found economical to timber. Sometimes the author has found it best to line the walls with 4½-in. work laid in cement mortar and carried up all round the reservoir at once, course by course. When four courses are built up, the concrete is filled in behind from the outside of the brickwork to the solid edge of the excavation; this is done so long as the wall is below ground level, and above the ground level concrete is laid to the width of the wall. Every fourth course of brickwork should consist of alternate headers and stretchers, so as to bond the brickwork into the concrete backing.

In adopting this form of construction there is a saving in the timbering, and also in the rendering, since brickwork presents a more even surface than concrete and therefore does not take so much cement; also, brickwork forms a good material on which to apply the rendering; it may or may not be the most economical method. Where piers are to be constructed the floor and walls should be rendered 1-in. thick with cement mortar, and this rendering should be allowed to set hard before anything is built upon it. The watertightness of the reservoir will depend entirely upon the care with which this work is done.

The reservoir must be ventilated and there

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must be means of access from the roof manholes to the interior, such as an iron ladder. This is preferable to step irons, which are a source of weakness.

The lining to the reservoir must be very carefully examined when the work is finished; it should be wrapped over carefully, and any places which sound hollow or soft should be cut and made good. It will be well then to fill the reservoir with water and to let it stand for 12 hours, and note the amount that the water subsides. If the reservoir is really watertight it will not subside very much.

With regard to slight leakage from reservoirs, it should be remembered that rendering which is not worked to a polished face is apt to be porous, and the importance of working up the cement to a polished face becomes evident. In the author's opinion this should be obtained by trowelling the cement mortar and not by adding any skimming coat of neat cement.

There are other methods of making a reservoir watertight besides rendering with cement mortar. Bitumen sheeting is used for the purpose, and is satisfactory if properly protected. Asphalt is also used for lining walls and floors. It must be remembered that the asphalt or bitumen sheeting will not adhere to the walls like cement, and that they must be put in between two walls. Reservoirs made of concrete without any rendering are sometimes constructed, but in the author's opinion this is not a good principle, since it is practically impossible to prevent inequalities in the concrete.

Clay puddle is also used as a lining for service reservoirs under certain conditions. There are cases where the puddle is first laid over the floor and then the concrete floor is laid on the puddled clay, and the wall is filled up with puddle backing behind it. It does not seem right, however, to found masonry or concrete work on such a soft foundation, and it is difficult to see any advantage in making a reservoir of this type. In another type of puddle-lined reservoir the puddle forms the watertight material, and there is no heavy masonry upon it at all, the face of the puddled clay being merely paved with concrete or other suitable material to protect it. This type of reservoir is useful in cases where settlements are expected, such as over old coal workings. It is also a very economical form. In American practice, reservoirs are frequently lined with slabs of concrete, having asphalt joints which allow for expansion and contraction. Walls are also built upon the same principle, with an asphalt joint in the watertight surface at given intervals. Where pipes or fittings penetrate the watertight lining of a reservoir the greatest care must be taken to prevent leakage. Such sources of weakness must be avoided as far as possible.

FERRO-CONCRETE RESERVOIRS.

The chief advance that has been made in service reservoir construction during recent years is due to the use of ferro-concrete.

To consider the economy of ferro-concrete construction briefly it can be seen that the floor and walls being thinner in ferro-concrete, there ought to be a saving of excavation. A ferro-concrete floor can be made to span the soft places that under ordinary conditions would have to be excavated and filled with concrete under the floor of the reservoir, or which might necessitate lowering the whole floor, and this may mean a great saving.

The reservoir floor is generally a flat platform of concrete, resting upon a solid foundation. In such a case, unless it is desired to reinforce, in order to prevent temperature and shrinkage cracks, there is no need for reinforcement with steel bars. It frequently happens that a solid foundation is not found at this required level, and though it will support the water pressure on the floor, it may not be firm enough to support the vertical thrust of the piers. In this case the careful addition of steel bars in the floor where the piers occur will be of the greatest advantage.

In the construction of walls the possible saving by the use of ferro-concrete is great. Without going into detail, the case is much like that of a barrel with and without the hoops. If a barrel had no hoops, its sides would have to be increased in size, until in section they looked like an ordinary dam. By putting iron hoops round the barrel to take the tensile stresses which the wood itself could not take, the thickness of the side of the barrel is reduced to a minimum. The case is the same with a small circular ferro-concrete reservoir.

In the case of a rectangular reservoir the wall is kept from overturning by being thoroughly bonded into the floor, and by having buttresses at given intervals. It is a great objection against the use of buttresses in a retaining wall that when the pressure of the earth comes upon the back of the wall there is a tendency for the wall to come forward, leaving its buttress behind. In ferro-concrete work this objection disappears, since the buttress is

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securely tied to the vertical steel members of the wall by horizontal ties.

The most economical depth for ordinary service reservoirs is generally taken to be about 12 ft. Masonry and concrete low walls are much cheaper per foot in height than high walls. If, however, the walls are too low, the floor and roof area become so great that they more than counterbalance the saving of material in the walls. With ferro-concrete the case is entirely different. The higher the wall (within limits) the greater the proportionate saving in using ferro-concrete; this entirely alters the rule for economical depth.

The advantage of the rule of constructing the reservoir half in and half out of the ground is lessened to a great extent with ferro-concrete, for, while there is a great saving of material in making the top half of the wall a dam and the bottom half merely a retaining wall for earth, there is no such great advantage to be gained by sinking the ferro-concrete tank much below ground level. The difference in cost per foot of height between a ferro-concrete wall 6 ft. high and one 12 ft. high in a roofed reservoir, where the top of the wall is held by the roof and the bottom of the wall is held by the floor, being very small in proportion. In the case of a wall of this kind, where the steel bars in the roof and floor are securely fastened to the vertical steel bars in the wall, the wall ceases to be a retaining wall or dam in the ordinary sense, and becomes a girder, since it is securely supported at both ends and has an unequally distributed load, due to water pressure. The advantage in a case like this is that the strength of the structure can be calculated much more satisfactorily than where plain masonry is used. It is impossible to assume strength to resist tension in a masonry wall, whereas this can be done with ferro-concrete.

WATER MAINS.

With regard to the water mains, the size and position will, of course, depend upon the demand, and also upon the position of the places to be supplied; but it should be the object of the engineer to form circuits. Thus, if two 6-in. mains leave a reservoir and form a circuit round a whole district, or section of a district, it is clear that people at the far end of the loop, being able to draw their supply through two 6-in. pipes instead of one, will have a much greater quantity of water at their command. Also, the fact that water circulates keeps the whole system clean. In the case in question it is clear that the greater part of the 6-in. loop must have been laid in any case, because people on both sides of the district required water, and only the connecting bit is extra. In laying down a new system it would cost less to lay a loop than a single main, since the loop would supply twice as much water per minute as the single pipe, and its diameter might be correspondingly smaller. It is a good thing wherever possible, that branch mains should also form circuits. In this way there would be a good circulation throughout the system, and stagnation at any point would be impossible, and the largest supply under the greatest pressure possible would always be available.

The second object of the engineer designing the system is that the whole system should be under perfect control. Each section of the system should be so arranged that it can be cut off by closing its valves. Each branch should be governed by a valve where it leaves the main; each service pipe must, of course, be governed by its stop-cock placed near the main, and so on. Where there is a single main it should be broken up into sections as much as possible by stop-cocks. It can be broken up, for instance, into half-mile or quarter-mile sections, the smaller these sections are the better. In the case of a circuit it is well to have a valve at each end and one in the middle. It is false economy to leave out valves, since leakages must occur which have to be set right, and it is of great importance that as small a section of the district or system should be shut off as possible, and in the event of a big burst there will be less waste of water and less damage to property if the water can be shut off promptly.

Air valves should be fixed at the top of every rise, so that if an air lock does occur it can be removed. A small air valve that can be worked by hand easily from the top is the best arrangement.

At the bottom of every valley of importance in a district, wash-out valves should be fixed on the mains, so that grit or rust lying there could be washed out. They should also be fixed on every dead end. Great carelessness is sometimes displayed in the fixing of wash-outs in direct connection with sewers or low-lying foul ditches. The wash-out valve must be so arranged that under no circumstances would it be possible for foul water to get back into the mains.

Mains should be laid with 2 ft. 6 in. of earth

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over them. If this is not done, sooner or later there will come a severe frost, and the mains at the shallower levels will certainly burst.

Water mains above 1½ in. diameter are generally made of cast iron in England. The smaller pipes and service connections are of galvanized iron or lead. For these connections lead pipe is generally used. In localities where the water is soft, to act upon the lead, it is dangerous to use them, and iron pipes should then be used. For a long length of pipe lead is expensive, and galvanized iron should generally be used in such cases.

Where a short main of, say, 1½ in. in diameter has to be laid it would probably be best to lay it in galvanized iron pipes, but if it is of great length it will be worth while for reasons of economy to put in cast-iron coated pipes, such as, for instance, turned bored pipes.

There are one or two makers who are supplying steel or wrought-iron pipes of large and small diameters, with socket ends, for main laying. These pipes possess many advantages, having fewer joints, being lighter, and so on. It must not be forgotten that they are also thinner, and would probably not last so long as cast-iron pipes.

For large mains the riveted steel or wrought-iron pipes are practically never used in this country. They are lighter to handle because they are much thinner, but are liable to be pressed out of shape by pressure from the outside, and cannot be expected to have the life of cast-iron mains. When laid they are riveted up in place on the ground.

Pipes should be very carefully examined for cracks before laying. In the author's opinion the practice of tapping the pipe with a hammer is not a sufficient test. Small cracks may exist and give trouble later, and it is well worth while to look at each pipe as carefully as possible before laying. Rapping the pipe, of course, is useful, but should not be taken as a final test for any pipe under suspicion.

Water mains generally have caulked blue lead joints, but turned and bored pipes are generally good if properly laid under ordinary conditions where the foundation is solid. The caulked lead joint is made by caulking two or three laps of spun yarn into the socket after the spigot has been pressed into place. Next a roll of clay is fixed round the mouth of the socket so that lead can be poured in. Special iron clips are sometimes used for this purpose, or sometimes a piece of rope embedded in a roll of fireclay. The roll of clay may be best made on a board. Soft lead wire is sometimes used instead of spun yarn; also the substance known as lead wool could be used. Molten lead is next poured into the socket out of ladles, so that it runs continuously into the socket till it is full. If possible the sockets should face uphill where the pipes are laid on a gradient, so that the lead may run the right way without any tendency for air bubbles to be formed. The lead should not be overheated or it will set too hard to be caulked properly. It must be heated sufficiently to run easily round the joint, but no more. The heat of the lead is generally tested by holding a shaving or piece of paper in it, and seeing whether it is just scorched or burnt. The lead sets immediately in a small joint, the clip or clay plugging is then taken off, and the lump of lead left at the top of the joint, where a cup was formed to receive the lead, should be cut off with a chisel, and if the lead adheres too tightly to the pipe it can be eased off with a chisel, so that the joint may be caulked solid. The lead should project well beyond the socket at the start, and should be caulked with a tool nearly as thick as the space between spigot and socket, so that the metal is compressed and rammed solid. The caulking should proceed continuously round the joint till it is quite hard. Whether the joint is sufficiently caulked can be ascertained by trying it with a hammer and caulking tool; it should be solid and should not give when so tested.

Turned and bored joints are useful where the ground is level and the trench straight. They can be laid more easily and quickly than pipes with caulked lead joints, provided the men are used to the work. They are, however, quite rigid and concentric, and can therefore only be laid in straight lines. It is always well to insert a socket pipe with a lead joint, every now and then, say, at every tenth joint, so that there may be a little flexibility, and to allow for any little irregularity in the ground, and for expansion and contraction. The turned spigot joint fits exactly into the bored socket, and the pipe is driven home with a heavy wooden mallet, the machined surfaces being first smeared with red-lead. The socket behind the machined surfaces is sometimes filled with cement or red-lead to finish the joint, but in some cases the rusting of the machined surfaces is relied upon to make good any leakage if it does occur. The chief risk in laying turned and bored joints is due to the fact that inex-

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perienced men will over-drive the pipes and crack the sockets. It is not difficult for experienced men to avoid this.

With regard to hydrants, the author would like to point out the unsuitability of the ball hydrant to places in which the mains are subject to varying pressures, as it is liable to leak. The author once had to report upon the mains of a certain company, and it was imagined that much water was being lost owing to the leaking ball hydrants. This was found to be incorrect, however, since on inspection it was found that an iron plate with red-lead joints had been clamped down over the mouth of each hydrant by the engineer in charge, in order to prevent the town from being submerged.

Automatic frost plugs used with hydrants, and particularly with standpost hydrants, have, in the author's experience, failed to act and are not to be recommended.

AUSTRIAN COEFFICIENTS FOR THE TRANSMISSION OF HEAT THROUGH BUILDING MATERIALS*

By W. W. MACON

Feeling that the figures for the transmission of heat through building materials, as adopted by the Society of Austrian Engineers and Architects, might well be placed in the records of the American Society of Heating and Ventilating Engineers, especially as these figures allow for some interesting observations to be made in comparison with the present practice in this country, a translation was made of the published figures of that society, reducing the figures as given in the metric system to those of the English system here in use. Generally speaking, the coefficients are much higher than those regarded as high enough in this country, although it is understood that they are based on tests made in connection with the heating and ventilation of the new stock exchange at Budapest. The percentage increase or correction to be made for exposure or for the location of the rooms in a building is not so great as commonly employed in this country, but the difference is not enough to bring any equality in the total heat calculations.

For example, after the amount of transmitted heat is calculated for a given room an increase of 20 per cent. for a northern exposure is provided for, where it has been common to use as much as 35 in this country, and for east and west exposures the figures are increased by 15 per cent., whereas, a room with a western exposure is here subject to a factor increase of 35 per cent., and when on the east side of the building to one of 25 per cent., while a south room would have the calculation increased to say 15 per cent., where the Austrian figures do not allow for any increase for the southern exposure at all.

NOTE.—The figures in the following tables are the numbers of British thermal units per square foot of surface per hour for 100 degrees F. difference in temperature on opposite sides, other temperature differences being proportional, so that for 70 degrees difference the coefficients are 70 per cent. of those in the tables.

OUTSIDE WALLS.

	Brick						Concrete	
Thickness. Inches.	Plastered in and out	Plastered inside.	With 2-in. air space.	With 1-in. air space.	Sandstone.	Limestone.	Ordinary.	With air space.
8...	72	78	..	41	...	...	89	54.5
12...	56	61	48.5	35	104	115.5	77	50
16...	46	50	39.5	31	91.5	101.5	67	46
24...	34.5	37	30	..	73	80.5	54	39.5
32...	27	29	24	..	60	67	45.5	34.5
40...	22.5	23.5	20	..	52	57	39	30.5

FLOORS AND ROOFING.

Plaster ceiling, planks, filling, double wood floor, 10.

Single wood floor, 59.

Plaster ceiling, air space, filling and soft wood floor, with cold air above, 18; do. with cold air under, 8.8.

*Discussion before the American Society of Heating and Ventilating Engineers.

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Plaster ceiling, air space, filling and double floor, with cold air above, 15.8; do., with cold air under, 8.1.

Reinforced concrete ceiling with double flooring, 43.

Reinforced concrete ceiling with double flooring and plaster ceiling inclosing an air space, 33.6.

Reinforced concrete ceiling, with plaster expanded metal construction, concrete with expanding metal, filling and double flooring:

6-in. beam..28	12-in. beam..17
8-in. beam..22	15-in. beam..14
10-in. beam..19	20-in. beam..13

Reinforced concrete roof, with plaster, inclosing an air space, cement with expanded metal reinforcing, asphalt and gravel covering, 36.

Reinforced concrete roof without air space, 103.

Tar paper on 1-in. boards, 78.5.

Zinc and copper roofing on 1-in. boards, 80.

Slate roofing on 1-in. boards, 77.

Tiling, without boards, 178.

Corrugated iron, without boards, 383.

WINDOWS AND SKYLIGHTS.

Single windows (⅛ in.), 195, (¼ in.), 192.

Double windows, 84.5.

Wired glass, 188.

Single skylight, 206.

Double skylight, 86.5.

DOORS.

Thickness. Inches.	Soft wood—Inner.	Soft wood—Outer.	Hard wood—Inner.	Hard wood—Outer.
¾	82	80	108	125
1	70	76	98	113
1½	56	60	85	95
2	47	50	75	83
2½	38	41	66	73

PARTITIONS AND INNER WALLS.

Thickness. Inches.	Wood	Wood plastered both sides.	Plaster construction. Ordinary.*	Plaster construction.
⅜	100	..	..	..
½	94	..	..	..
¾	79	48	..	..
1	74	44	..	..
1½	..	38	115	112
2	..	..	110	106
2½	..	..	101	100
3	..	..	94	94
3½	..	..	89	90
4	..	..	84	85

*Brick partition walls plastered about 10 per cent. less than outside plastered brick walls.

WATERPROOFING CEMENT STRUCTURES*

By JAMES L. DAVIS

Generous use of Portland cement will secure impervious concrete. Several structures, such as reinforced dams, standpipes and tanks have been successfully built with the concrete mixed in the ordinary manner in proportions about 1:2:4 or 1:2:3, without special care other than to secure a wet consistency. Tests not here given show that ordinary sands in mortar in proportions 1:2½ or richer are impervious. Also, so-called sand or silica cements make a somewhat tighter mortar than Portland cements.

By scientifically grading the aggregate, Mr. Wm. B. Fuller has successfully built tanks with thin walls, of proportions about 1:3:7. Whether it is cheaper to use the larger quantity of cement or to grade the aggregate depends upon the relative local prices of cement and of aggregate, and the size of the work. These are the proved methods that are free from doubt as to enduring efficiency and strength, and are of reasonable costs.

It should be remembered that troweling on a plaster coat of mortar or washing with thin grout are but modifications of use of rich proportions of Portland cement.

The use of finer sand than is usually accepted for ordinary concrete work may prove to be of special value. Its advantage, if successful, will consist simply in cheapening the process of grading ordinary materials to an ideal analysis. Its effects on reducing strength is well known, and its use will in some cases be limited by strength requirements.

Puzzolan and sand cements are superior to Portlands in securing impermeability, but they are somewhat inferior in strength. Colloidal clay as a substitute for five per cent. and ten per cent. of the sand, or the substitution of one per cent. or two and a half per cent. solutions of alum sulphate, or possibly other electrolytes for the mixing water, may prove cheap and effective processes. The writer holds aloof from stronger recommendations at this time because of the limited range of the experiments, and the undetermined effect on

*From a paper read before the National Association of Cement Users, Buffalo, Jan. 20-25, 1908.

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permanence of strength. Successful application of the clay process would require special appliances for drying, pulverizing and mixing.

The degree of imperviousness which may be expected from methods above described is such as to meet ordinary conditions, as the demand for dry basements, roofs and walls, and the storage of water or its conveyance under moderate heads without objectionable loss or resulting damage from its escape.

Two questions of great importance, the solution of which are being sought, are whether a greater degree of protection for reinforcing steel than can now be secured is necessary, and whether it is practicable to construct in reinforced concrete to resist hydrostatic heads of 100 to 300 feet, such as is demanded for great dams and pressure conduits.

One of the results of investigations at the laboratory of the Board of Water Supply of the City of New York, of which the writer has charge, has been to confirm the often observed phenomenon of increasing imperviousness with time, commonly called the result of the "silting up" of the concrete. The action has not been fully explained, but whether it is physical or chemical, or whether it has some analogy to the schmutz-decke of the fine sand-filter, he who would construct impervious concrete may count upon its coming to his aid at least under conditions of moderate head of water in continued contact.

One set of experiments with mixtures as lean as 1:4:14 intended to secure the maximum possible degree of permeability to serve as drainage blocks through which seepage of water might be carried away, became so nearly impervious in twenty-four hours under a head of twenty inches as to make their use for the purpose intended doubtful. This was with the flow perpendicular to the bed of the blocks. With the blocks so placed that the flow was parallel to the bed, the flow was greatly increased.

The difficulties in securing perfect workmanship in mixing and placing the concrete, and avoiding the formation of bedding planes through the mass, are greater than are those resulting from lack of knowledge of what should be done.

THE ADVANTAGES AND DISADVANTAGES OF SUPERHEATED STEAM

FROM "THE ENGINEER," LONDON

In the course of a recent discussion of this subject before the Manchester Association of Engineers, Mr. Michael Longridge referred first to the two chief types of apparatus, namely, those which are independently fired, and those placed in the downtakes of boilers. He said much difficulty had been experienced in keeping stop valves and their glands tight, but that had been remedied by the use of nickel alloys in the valves and seatings and nickel steel for the spindles. Corliss valves could be used on engines with heat as high as 500° F., and piston and double-beat valves for all ordinary temperatures. Referring to the difficulty caused by pistons seizing owing to defective lubrication, presence of water, or distortion of the cylinders due to irregular expansion, troubles of this kind, Mr. Longridge said, could be remedied by allowing greater clearance between the piston and cylinder walls. With regard to the cost of superheating, a calculation made showed that to obtain 200° of superheat, the extra heat required from the fuel was about 8.9%. To get a steam temperature of 500 to 600° F. with a superheater of reasonable heating surface a gas temperature of 1,000 to 1,200° was necessary. Another calculation showed that with a Lancashire boiler working at 150 lbs. pressure, 945,000 units of superheat could be obtained at a cost of 480,000 B.T.U. per hour, or 5% of the total heat entering the boiler.

With regard to the advantages derived from the use of superheated steam with reciprocating engines, the author of the communication stated that by getting rid of the moisture in the steam by superheating the surface condensation was reduced, and if it were possible to keep the steam dry throughout the whole stroke and its temperature up to the saturation temperature the action of the metal in the cylinder could be suppressed entirely. Mr. Longridge, however, showed by diagrams that these temperatures would require to be so high that

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such a procedure was impossible unless the fall of pressure was very slight. Quoting from the reports of trials made by French boiler insurance companies an average gain of 10% of steam and 11% of coal was effected by the use of superheated steam in simple engines and a saving of 23% in steam and 21% in fuel for compound engines. Mr. Longridge said it seemed obvious that there was a distinct saving effected by using superheated steam, but a reliable formula which took into consideration all the many conditions that should enter into the calculation did not exist.

Dr. John Nicolson stated that, as a result of recent experiments, it had been found that a relatively small amount of superheat, by preventing the formation and deposition of moisture in the steam, will therefore cause a considerable rise of wall temperature with early cut-offs.

He gave a roughly correct formula: $\theta = 0.75t$, for the relation between the clearance-wall temperature θ and the actual temperature t of the superheated steam entering the cylinder, when the superheat is considerable or great.

This relation is not only of scientific interest, but also of great practical importance. By its use can be predicted the amount of superheat required to raise the wall temperature (of the clearance) up to that temperaure which corresponds to the saturation pressure of the steam admitted to the cylinder. Thus, if steam of 360° F. saturation temperature is being worked with the superheated steam it must, when entering, have a temperature of 480° F. to raise the cover up to 360°. As no initial condensation can take place if the cylinder walls are hotter than the saturation temperature corresponding to the pressure, we see that in this case 120° F. of superheat will suffice altogether to prevent initial condensation.

It by no means follows, however, that an amount of superheat sufficient merely to raise the clearance wall temperature up to that corresponding to saturation will eliminate the whole of the "missing quantity." There is still the effect of valve leakage to be got rid of. A small amount of superheat has a very marked effect in reducing the amount of such leakage, more especially with slide valves, and this irrespective of whether the cut-off is early or late; but even when the superheat is large enough to eliminate cylinder condensation in the manner just described, there still remains in many cases a considerable missing quantity to be accounted for. This remainder can only be ascribed to leakage.

FIRES IN MINES: THEIR EXTINGUISHMENT BY SULPHUR DIOXIDE*

By WALTER O. SNELLING†

In combating mine fires the use of carbon dioxide as a means of producing an atmosphere in which combustion cannot be sustained, has been many times suggested, and frequently tried, generally with a fair degree of success. The cost of producing carbon dioxide has been, however, a decided drawback, and the danger of producing carbon monoxide by the reduction of the carbon dioxide by heated carbon, and consequently bringing about an explosion, has also tended to prevent this method from being used.

The use of sulphur dioxide in combating mine fires has not, I believe, been previously suggested or tried, and yet the method presents such decided advantages over the use of carbon dioxide, that I now suggest the advisability of considering it as a cheap, convenient and safe means for fighting stubborn mine fires, and I herewith present some statements to show the advantages which this method would possess.

Cost, Preparation, Etc.—Sulphur dioxide is produced by the simple burning of brimstone on a grate of suitable kind, and of such nature as could be quickly constructed, even by inexperienced men. One ton of brimstone, costing $40 will produce 25,000 cu. ft. of gas, and allowing for all sources of loss, it is probable that sulphur dioxide can be produced for $2 per 1,000 cu. ft. For carbon dioxide, produced by the action of sulphuric acid on limestone, the best estimate I have been able to figure is

*From a paper read before the American Institute of Mining Engineers, Feb. 19, 1908.
†Explosives Chemist of the United States Government.

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about $4 per $1,000 cu. ft. or twice as costly as the sulphur dioxide.

Efficiency.—Sulphur dioxide is more efficient than carbon dioxide in the putting out of fire. Neither coal nor any other combustible material can possibly burn in an atmosphere containing any considerable quantity of sulphur dioxide. Sulphur dioxide is very heavy, being almost twice as heavy as carbon dioxide (1 cu. ft. weighing 81 grams, while 1 cu. ft. of carbon dioxide weighs 46 grams) and consequently the sulphur dioxide will penetrate into gob piles, and in every way serve as an efficient agent in finding its way into every part of the region of the mine into which it is introduced.

Safety.—None of the dangers incident to the use of carbon dioxide are present with sulphur dioxide. No explosive lower oxides are produced, or can be produced by the reduction of sulphur dioxide. Still more important, the danger always present when using carbon dioxide, of men getting into the gas without knowing of its presence and suffocating, is absent when sulphur dioxide is used, since its strong odor gives instant warning when but a small fraction of one per cent of the gas is present in the air.

Other Advantages.—Any leakage of carbon dioxide from a mine can only with great difficulty be detected. Frequently, in places where this method has been applied, it is probable that millions of cubic feet of the gas have escaped through unknown fissures in the rock. Any leakage of sulphur dioxide would quickly make itself known, and the openings could accordingly be closed before more than a small portion of the gas had escaped.

CREOSOTING DOUGLAS FIR*

By DAVID ALLERTON

Douglas fir varies in its structural condition of fiber, is very refractory to treatment, and is injured by high temperature or long continued steaming, and in treating a number of pieces there will be considerable difference in penetration. In sawed timber much of this difference is due to the mode of sawing. The timber has a hard and soft side; in one a penetration of perhaps an inch is obtained and in the other twice as much. In seasoned fir piling some pieces of the same charge will show 2 ins. and some 4½ ins. The penetration varies also in different parts of the same pile.

To treat seasoned timber without steaming, the cylinders must contain steam pipes to keep the solution hot and to bring the wood up to the same temperature, and the pressure must be gradual. If this process is followed the impregnation will be as thorough as if the wood were steamed, and there will be no subsequent drip.

The method in the case of seasoned fir is to place the wood in a sealed retort and to turn the steam into the coils, the creosote being introduced at a temperature of 170° F. Time was allowed for the exterior of the wood to become of equal temperature with the oil (about an hour), the temperature during the process being kept at 175° to 180° F. Pressure was started very gradually to allow the injected oil to follow the expanded and heated cells, for if the pressure was suddenly raised the contraction of the outer fiber effectually stopped the absorption, opposing, as it were, a dead wall. By gradually increasing the pressure the oil in the gradually expanding cells was forced still farther in by the increased pressure of the oil behind. In this way a penetration in seasoned fir of 2 to 4½ ins. in piling, the treatment taking 12 to 14 hours was obtained.

Green fir was treated by the "open tank" method. This consisted of two treatments. The preliminary treatment was the same as mentioned for seasoned fir, except that the water in the wood being expanded and replaced by the heavier creosote, and rising to the top of the retort was drawn off through a standpipe connected with a ¼-in. pipe and valve. After 12 hours' pressure the oil was drawn off and the wood and retort cooled for 12 hours, when the process was repeated, another grad-

*From a paper read at the annual meeting of the United States Wood Preservers' Association at Kansas City, Mo., Jan 21-23.

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ual pressure being maintained for 12 hours. We found that we injected the most oil in the first 12 hours, but got our penetration in the second 12 hours. The average penetration was 1 to 2 ins. This process, with inferior results and consuming 36 hours, is not desirable unless necessary. Both processes require the supervision of an expert or skilled help, for if temperature and pressure are not properly regulated the result will not be satisfactory.

The principle involved in this mode of treatment is to have the wood warmed to as near as possible the temperature of the fluid to be injected. It is apparent that the attempt to force a hot solution into cold, refractory wood must result in failure, but by giving the wood time to expand and the heat time to penetrate toward the center of the timber it is found that the fluid is gradually forced in, in proportion as the interior heat increases.

RIVETING VS. WELDING

FROM "THE BOILER MAKER"

It has been estimated in the case of a 72-in. by 18-ft. horizontal tubular boiler built to withstand a pressure of 125 lbs. per sq. in. that the total cost of labor and material used in the boiler would be about $561, of which 80% is the cost of material, and 20% is the cost of labor. Of this amount, the cost of labor on the riveted joints alone—that is, of laying out the riveted holes, punching, riveting, etc.,—is about 19% of the cost of labor, and 3.7% of the total cost of the boiler. The additional material; that is, butt straps or laps and rivets costs about 5% of the cost of material and 3.8% of the total cost of the boiler. Therefore, the cost of the riveted joints alone is about 8% of the total cost of the boiler. This is assuming that the longitudinal joint is a double riveted butt joint and that the holes are punched and all rivets driven on the bull machine.

The only possible substitute for riveting seems to be some form of welding in which the metal itself is structurally united in such a manner that the finished product forms one homogeneous piece of uniform quality and properties throughout. Furthermore, in order for such a system to be of any practical use, the tensile strength of the welded joint must be as great or greater than that of a riveted joint, and the cost of doing the work, including the fixed charges on the apparatus, must not be greater than the cost of riveting; that is, it must be less than 8% or 10% of the total cost of the boiler.

The ordinary method of welding by mechanical means, such as hammering, cannot be used in welding boiler shells, both for practical reasons and because the strength of a weld made in this manner is always uncertain. There has recently come into use, however, a system known as autogenous welding, in which the metal itself is raised to a temperature sufficiently high to cause it to be its own joining material; that is, the parts are joined together by the fusion of their own substance without mechanical aid.

A recent development of this system is the use of the oxyacetylene blowpipe, and this seems to have been fairly successful, since a very high temperature (3,000° F.) can be obtained with it, so that even thick plates can be welded rapidly without the use of an excessive amount of fuel. Both oxygen and acetylene can be produced or obtained commercially at a reasonable price, and the apparatus required is not very complicated, the blowpipe itself being a small brass instrument weighing only about 2 lbs., which can be readily handled by an inexperienced workman.

At present, the use of autogenous welding will probably be confined to repair work, for which it seems particularly well adapted on account of its portability. It certainly will not be used for welding the seams of large boilers or pressure tanks until it is absolutely known that a reliable weld can be made which will be at least 85% as strong as the metal itself.

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NOTES ON ENGINEERING AND APPLIED SCIENCE

FROM ALL SOURCES

Chemical Sterilization of Drinking Water.—Messrs. Palerno and Cinngolani, the inventors of "tachyol," (fluoride of silver), an antiseptic employed in surgery, have found that a solution of 1 part in 500,000 of water will destroy all germs, including B. subtilis, its germicidal effect being much greater than that of chlorine, bromine or ozone.

International Atomic Weights.—The international committee on atomic weights has recently announced the changes in the list of elements for 1908. These are, with one exception, practically the same as those announced for 1907. The only notable change is the addition of a new element, Dysprosium, whose atomic weight is given as 162.5, to the list.

A Novel Fire-Detecting Device consists of a fine copper wire core, encased in fusible metal, which, in turn, is covered with insulating material, the whole being contained in a copper tube, about 1-10 in. in diameter. This wire is strung the same as ordinary bell wire, or used in short sections attached to terminals and mounted on porcelain blocks in the form of a thermostat. When the temperature rises to the point at which the wire is designed to operate, 160. 200 or 370 degrees F., the fusible alloy softens and expands through the meshes of the insulation against the inner surface of the copper tube, thus forming a positive and permanent contact between the latter and the core wire, and causing the alarm bells to continue ringing until either the battery is exhausted or the circuit is intentionally broken.

A New Insulating Material, which is claimed to have a high specific resistance approaching that of gutta-percha and porcelain, has been recently patented by Herr Muller, a German inventor. The substance is almost incombustible, as it will even stand exposure for a short time to the electric arc without burning. Its composition is as follows: 100 parts of mineral pitch are dissolved in 20 parts of a volatile solvent (e. g., benzine), and from 25 to 75 parts of this solution are added to 100 parts of finely-ground asbestos. The mixture is then submitted to very great pressure, and is dried at a low temperature to expel the whole of the solvent.

The Effect of Alum and Clay in the Waterproofing of Concrete.—Portland cement liberates on the addition of water, free lime, which, uniting with water, forms a hydrate. Ordinary alum being sulphate of potash and aluminum, the reaction between the lime and alum results in the precipitation of aluminum hydrate, which forms as a colloid or gelatinous precipitate and tends to decrease permeability by decreasing the voids. Plastic clays are formed by the decomposition of rocks such as feldspar (a silicate of aluminum, sodium and postassium), and these silicates possess a mechanical ability in closing the voids in concrete. Regarding the probable effect of the addition of alum and clay it is known to some engineers that the presence of sulphates and alumina in cement is not desirable above certain limitations, owing to their accelerating action on the set, loss in ultimate strength, possible expansion of the sulphates when used in water, and their disintegrating effect in seawater.—S. A. Brown in Engineering News.

Canal-Boat Haulage.—For canal boats, such as are used on the Lehigh and Delaware canals, the effective tow-rope pull (in pounds) required for any number of loaded boats is expressed approximately by the formula $0.45V^2T$, and for empty boats by $0.67V^2T$, when V is the speed in miles per hour and T the total weight in tons of 2,000 lbs. The boats used on these canals are 87½ ft. in length, 10 ft. 5 ins. wide, and have a draft (loaded) of 5 ft. 2 ins.; weight, empty, 23.8 tons; loaded, 137 tons. The ratio of immersed cross-section of a loaded boat to the canal section is about 1 to 8. Speed, as fixed by conditions of steering: single boats, up to 5 mi./hr.; two-boat tows, 3.5-4 mi./hr.; four-boat tows, up to 3 mi./hr., except on sharp curves. The energy required in watt-hours per ton-mile at the trolleys of the mining locomotives or tractors

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used for towing, is approximately 12 for four-boat tows, 16 for two-boat tows, and 22 for single boats.—From data in a paper entitled "Notes on Electric Haulage of Canal Boats," by L. B. Stillwell and H. S. Putnam, read before the A. I. E. E., Mar. 13, 1908.

The Use of Glycerine in Radiators.—A reliable anti-freezing mixture for use in radiators is a 20% solution of glycerine in water. This freezes at 17° F. For very cold climates a 30% solution which freezes at 10° F., may be used but for ordinary purposes the 20% solution will prove very satisfactory. Crude glycerine should not be used, as it contains about 10% of sodium salts, which may cause a deposit on the tubes of the radiator. What is known commercially as "pale distilled" glycerine may be used. This contains only 0.1% of salt, a quantity so small as to preclude the incrustation of the tubes. The glycerine is not affected by a temperature of 210° F. and needs replacement only at very long intervals. The glycerine and water should be mixed before being put into the radiator or the glycerine may be poured in after the water while the engine is running. Under no circumstances should the glycerine be poured in before the water as it has a much higher specific gravity than the water and will, consequently, when circulation begins, lodge in the water jackets, restrict the free circulation of the water and cause possible serious overheating.—Condensed from "The Commercial Motor."

Live-Steam Feed-Water Heating.—Many tests which have been made appear to show that some economy results from the use of live steam in feed-water heating, but it is difficult to see how any saving can be effected by taking live steam from a boiler and immediately returning it thereto when mixed with feed-water. There are indirect advantages in this method, but they consist for the most part in greater uniformity of working, the avoidance of straining, and in the consequent saving of wear and tear on the boilers. An exhaustive test was recently made by Prof. John Goodman and Mr. D. R. MacLachlan on a 14-ft. return tubular boiler, 96 ins. in diameter, having 60 3-in. tubes and two 6-ft. furnaces each 30 ins. in diameter. This boiler was tested for 12 hours at an output of 5,000 lbs. of steam per hour, both with and without the live-steam heater. The results of the two tests, as given in a paper read before the Institution of Mechanical Engineers, show that the boiler evaporated almost exactly the same quantity of water per pound of coal both when the heater was in use and when not in use. The only advantage discernible from the use of the heater was that the deposit in the boiler was materially less when the heater was used than when the feed water passed direct to the boiler.

Moisture and the Strength of Wood.—The United States Forest Service made some time ago a thorough study of this question. The results of its investigations are interesting and instructive. It has been found that the relation of moisture to strength follows a definite law. The strength of all kinds of wood increases rapidly with proper drying, the amount of increase depending on the species and the degree of dryness. Thus the strength of a piece of unseasoned red spruce may be increased over 400% by a thorough drying at the temperature of boiling water. But the strength decreases again as the wood reabsorbs moisture. Air-dried wood protected from the weather, and containing 12% of moisture is, according to species, 1.7 to 2.4 times stronger than when green. Drying also increases the stiffness of wood. These conclusions have been drawn from pieces of small cross-section, not exceeding 4 ins. by 4 ins. Large timber requires years of drying before the moisture is reduced to the point at which the strength begins to increase. It has been found that, under normal conditions, wood fiber will absorb a definite amount of moisture. Additional water only fills the pores. It has also been found that the water which simply fills the pores has no effect on the strength. The fiber saturation points are: For longleaf pine, 25; red spruce, 31; chestnut, 25; red gum, 25; red fir, 23; white ash, 20.5; Norway pine, 30%, estimated on the dry weight of the wood. Timber that has been dried and resoaked is slightly weaker than when green.—"Engineering Times."

A New Lubricant Testing-Machine.—The Blake consists of a vertical shaft driven by a pulley and belt, with a conical cup on its upper end. Into the cup is accurately fitted a metal cone, on the top of which is a vertical spindle; to this are fitted two horizontal arms, with vanes attached to give air resistance. A revolution-counter is connected to the revolv-

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ing cup, and another to the revolving cone inside the cup.

The machine works as follows: A small quantity of the oil or lubricant to be tested is placed in the cup, and the loose cone, with its vertical spindle and vanes, is placed in the cup; the cone has a groove in its side, in which a small quanaity of oil may remain. The lower spindle, with the cup attached, is then made to revolve quickly for several hours, for example; and as the cup revolves with the cone inside it, the friction between the cup and the cone causes the latter to revolve also, but at a slower speed than the cup, on account of the resistance offered by the vanes beating the atmosphere. After the machine has been running for a given time the number of revolutions made by the cup and those made by the cone are noted, and a record made of them. Then a second oil or lubricant is put in, after first removing completely all traces of the one previously tested, and a note made of the revolutions made respectively by the cup and cone during the same period of time as the first test. If the number of revolutions made by the cone be less with the second oil or lubricant than with the first, it naturally follows that the friction between the cup and the cone has been less, and therefore that the second oil or lubricant is the better. Many oils can be compared in this way, and their lubricating value written down in the exact order of merit. For testing "heavy" oils a lever and weight are used for giving the requisite pressure between the cone and the cup.—"Engineering."

Vanadium in Cast Iron.—By the use of vanadium in steel the elastic limit is increased without an impairment of the ductility of the steel—that is, an exceedingly strong steel is obtained, with its softness still remaining. Coupled with these most valuable properties is another, and that is the extreme resistance to deterioration when the metal is subjected to severe and continued strains in service. Vanadium steel is nonfatiguing, and, therefore, an ideal railroad and rolling mill metal. It is but natural that attention should be drawn to the use of vanadium in the foundry. The very first casting which might be benefited is the car wheel. Next would come the various kinds of rolls, then alkali pots, pump parts, etc.—wherever strains are heavy and oft-repeated, either direct tension and compression alternately and in cases where castings are subjected to shock or great variations in temperature. In order to learn something of the effects of vanadium on cast iron a series of tests was recently conducted by Dr. Richard Moldenke, using melted scrapped car wheels for white iron and a good machinery pig iron for a variety of gray iron. A ferrovanadium alloy (powdered) carrying high carbon was selected because it melted at a lower temperature and would also be cheaper for the foundryman. Inasmuch as vanadium, besides being a great strengthener, is also a powerful deoxidizing agent, and the increase in strength obtained by its use might be attributed to the purification of the iron only, 80 per cent. ferromanganese was added in sufficient quantity to add 0.5 per cent. of manganese, and then the ferrovanadium. The tests seem to confirm the belief that the addition to the strength of the metal is a well founded one. The vanadium alloy used contained vanadium, 14.67%; carbon, 6.36%, and silicon, 0.18%. The results obtained show an increase in the breaking strength of a standard 1¼-in. round test bar from 2,000 lbs. to 2,500 lbs. for gray machinery iron containing 0.59% Mn and 0.25% V; and from 1,500 lbs. up to 3,900 lbs. for white iron (remelted car wheels) containing 0.54% Mn and 0.22% V. They are sufficient to warrant further investigation on the part of every foundryman who has special problems in strength to master, and Dr. Moldenke has therefore made public his preliminary investigations, instead of withholding them until further contemplated tests are completed.

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BOOK DEPARTMENT

ANALYSIS OF ELASTIC ARCHES.—Two-Hinged, Three-Hinged and Hingeless, of Steel, Masonry and Concrete. By Joseph W. Balet, C. E. New York: The Engineering News Publishing Co. Cloth; 6 × 9 ins.; pp. 320; with 184 diagrams (including 6 folding plates) and 19 tables. $3, net.

Reviewed by FRANK P. McKIBBEN.*

Designing engineers peruse with interest any new book that deals with the analysis and design of arches. A few attempts have been made to place the design of these structures on a practical working basis, but as yet no book has fulfilled the requirements. This work of Mr. Balet is in some respects a step in advance of anything yet attempted in English. The author not only presents an extended discussion of the theory involved, but he also devotes considerable attention to the application of the theory to the design of the structure. The work exhibits an exceptional knowledge of mathematics and mechanics on the part of the author.

Hingeless arches, and arches with two and also with three hinges, are treated principally by graphical methods. The reactions due to the loads on the structure are studied by means of "intersection loci" and "tangent curves." "Intersection loci" are what others have called "reaction loci" or "position lines."

Chapter I. is devoted principally to definitions. In Chapter II. three-hinged arches, with braced as well as solid ribs, are treated at some length. The three-hinged arch is statically determined as regards the outer forces, and therefore can be treated without the aid of the theory of elasticity. In a treatise on elastic arches, however, the analysis of the three-hinged arch is not out of place, if for no other reason than that of completeness. A little attention is given in Chapter II. to the three-hinged arch rib of masonry, concrete or reinforced concrete.

The greater part of the book, covered by Chapters III. and IV., is devoted to the study of the two-hinged and the hingeless arches. It is in these two chapters that the most valuable part of the work lies. The stresses in the two-hinged arch are analyzed with the aid of the "intersection loci," and those of the hingeless arch by the "intersection loci" and the "tangent curves."

Chapter V. is devoted to the distribution of stresses in arch and other sections, to formulas for mansory and reinforced concrete columns, to bending moments and shears in beams, and to flexural stresses in reinforced concrete beams. In the latter case, the compression in the concrete above the neutral axis of the cross-section of the beam is assumed to vary in accordance with the parabolic curve. On page 205 the maximum allowable compressive stress in concrete is given as 400 pounds per square inch, and the shearing stress not greater than 50 pounds per square inch. In short, plain concrete columns in which the unit stress is 400 pounds, the shearing stress will be much greater than the specified allowance of 50 pounds per square inch. Concrete in shear can safely carry considerably more than 50 pounds per square inch. The allowance given is the one usually specified where it is intended to take account of tension on the diagonal lines in beams.

In Chapter VI., under the title "Stresses Caused by Lateral Wind Pressure," four pages are devoted to this subject. The remainder of the chapter, twenty-six pages, is devoted to the discussion of loads on arches, determination of the type of arch, comparison of stresses and deflections in the three types of arches, dimensions of existing arches, etc. The mathematical work necessary to deduce the various formulas is principally set forth in an appendix of seventy-two pages.

The book is difficult to read, due partly to the arrangement of the subject matter. References to subsequent chapters should be avoided as much as possible in any work. In arranging a book dealing with a subject as complicated as the analysis of the elastic arch, one should take great pains to have the subject matter logically and clearly set forth, and to have the diagrams so well made that

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the reader can easily follow them. With the book in question, many of the diagrams are not clear. The work shows a keen insight into the mathematics and the theory of the arch, and the engineer who is well-versed in mathematics and mechanics will derive benefit from studying the book, but the beginner will find difficulty in following the subject as here set forth.

THE METALLURGY OF IRON AND STEEL.—By Bradley Stoughton, Ph. B., B. S., Adjunct Professor, School of Mines, Columbia University. New York: Hill Publishing Co. Cloth; 6 × 9½ ins.; pp. 509; 319 illustrations in the text and 33 tables. $3, net.

This new work of Prof. Stoughton is designed both as a text-book for colleges and as a reference work for all who are engaged or interested in the manufacture of iron and steel. It is altogether a most complete and valuable work, as it gives the best methods of production and in addition records in a thorough and practical manner the most recent advances in the subjects of metallography, corrosion and the new alloys. The book assumes on the part of the readers a knowledge of the fundamental principles of chemistry and physics, but for those who have not had training in these subjects or whose knowledge of these sciences has become somewhat unreliable, a chapter is inserted covering the chemical and physical principles involved in metallurgical operations. The section on chemistry in this chapter is especially well written and many text-books on the subject could be improved if their writers were to use the clear and direct methods employed by Prof. Stoughton. The book opens with a chapter on iron and carbon, defining and discussing the various kinds of iron and giving a bibliography of references to works and periodicals dealing with the metallurgy of iron and steel. Chapter II. takes up the manufacture of pig iron, discusses the principles involved and describes the methods of production. Chapter III. is devoted to an exposition of the various processes employed for the purification of pig iron and a comparison of these processes is made. In the fourth chapter the author discusses the manufacture of wrought iron and crucible steel, and in the following two chapters the Bessemer and open-hearth processes. Chapter VII. takes up the subject of defects in ingots and other castings and in Chapter VIII. the methods employed in the mechanical treatment of steel are considered in detail. Chapter IX. deals with iron and steel founding, the making of molds, the design of patterns, cupola practice, the melting of steel for castings, etc. The succeeding three chapters are devoted to the discussion of the solution theory of iron and steel, and the constitution of steel and cast iron. Chapter XIV. takes up the heat treatment of steel, discussing improper heating, methods of hardening and the constitution of hardened and tempered steels. The alloy steels form the subject of Chapter XV., the alloys with nickel, manganese, chromium, silicon, vanadium and titanium being treated of, as well as self-hardening and high-speed tool steels. In Chapter XVI. the author gives the most recent theories regarding the corrosion of steel and describes the best preservative coatings and their action. Chapter XVII. deals with the electro-metallurgy of iron and steel. In this section the various electro-thermic processes and furnaces for the manufacture of pig iron and steel are described and compared, and electrolytic methods for the refining of iron are given. Chapter XVIII. takes up the metallography of iron and steel, giving a full discussion of the various sides of the subject. The final chapter is that previously mentioned as giving a review of the principles of chemistry and physics necessary to undertake the study of metallurgy. An excellent feature of the book is that at the end of each chapter full references to the bibliography of the subject dealt with in that particular section are given. Prof. Stoughton's work will undoubtedly find a wide sale among metallurgists and students on account of the thorough manner and clear style in which he has treated the subject.

PRACTICAL STEAM AND HOT WATER HEATING AND VENTILATION.—By Alfred G. King. New York: The Norman W. Henley Publishing Co. Cloth; 6½ × 9½ ins.; pp. 402; 303 illustrations in the text. $3.

This work is one of the most complete and exhaustive yet published on this branch of domestic engineering. Heating contractors, architects and builders, as well as steam fitters and plumbers, will find it an excellent presentation of the most up-to-date practice in the design of heating and ventilating systems. After an introductory chapter the author takes up heat, its nature, measurement and transmission. Chapter III. is devoted to the evolution of heating apparatus and Chapter IV. deals with boiler surfaces and fittings. The construction of the chimney flue is next considered. This is followed by a chapter on pipes and fittings and one on air valves. The

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general subject of radiation is then taken up, the forms of radiating surfaces described, the proper location of radiators discussed and rules for estimating radiation for steam and hot water given. The next two chapters give the essential features of steam-heating apparatus, the subject of exhaust-steam heating being given a full treatment. Hot-water heating and apparatus is then discussed and various systems are described. Miscellaneous heating is next considered and the vacuum vapor and vacuum exhaust systems are discussed. The author then takes up the question of radiator and pipe connections, and this is followed by a thorough though rather brief treatment of the subject of ventilation. The remaining chapters in the book take up the questions of steam appliances in general, central-station heating, pipe and boiler coverings, temperature regulation and heat control, business methods, contracts, specifications, and other miscellaneous details.

A TEXT-BOOK OF ELECTRO-CHEMISTRY.— By Max Le Blanc, Professor in the University of Leipzig. Translated from the Fourth Enlarged German Edition, by Willis R. Whitney, Ph. D., Director of the Research Laboratory of the General Electric Company, and John W. Brown, Ph. D., Director of the Research and Battery Laboratory of the National Carbon Company. New York: The Macmillan Company, 1907. Cloth; pp. xiv + 338; 9 × 6 ins.

Electro-chemistry is not a very young science. Volta devised his crown of cups in 1800. Following at various intervals of time came Davy's great discovery of the alkali metals, Faraday's discovery of the fundamental law called by his name, the development of the art of electroplating metals, Hittorf's work on the migration of ions, and Kohlrausch's conductivity measurements. A number of other fundamental facts were known before 1887, when Arrhenius proposed the dissociation theory of solution, but there was no one theory to bind the whole into one body of closely correlated facts. Consequently, previous to 1887 this branch of knowledge advanced but very slowly. On the other hand, since then it has grown with leaps and bounds, and numerous apparently unrelated facts have been shown to be really very closely related.

To write a book which shall comprehensively yet simply deal with this subject is a difficult task, yet in the book before us Le Blanc has placed at the disposal of the student a model of completeness and clearness of statement. Without doubt this is the one best recent book on the subject.

The first chapter deals with the forms of energy in general and their measurement.

The second chapter gives a sketch of the history of the subject.

The rest of the book treats in order of the theory of electrolytic dissociation, the migration of ions, the conductance of electrolytes, electrical endosmose, migration of suspended particles, electromotive force, electrolysis, polarization, and storage cells. An appendix contains extensive tables of notation. An author's index and a subject index, both very complete, close the volume.

No student of electro-chemistry can get along without this book.

The translation is finely done, the English showing practically no trace of the original German, a good point which cannot always be said of translations of scientific works. In a few cases the translators have added important original material, such addition being always clearly indicated.

Throughout the book diagrams are freely employed to make the statements clear. There are also numerous tables of electro-chemical properties of matter. The mathematical treatment is always simple and lucid, requiring in most cases scarcely more than an elementary knowledge of algebra on the part of the reader.

Misprints are very few. A careful reading of the whole book only disclosed the following, namely, on page 2, line 8, A for a, and in line 11, d for l. On page 59, line 7, Mg Cl for $Mg Cl_2$.

The paper, print and binding are good.

AN INTRODUCTION TO THE STUDY OF ELECTRICAL ENGINEERING. — By Henry H. Norris. Professor of Electrical Engineering in Sibley College, Cornell University. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. 404; illustrated. $2.50.

The plan of this introductory work is to take examples from the every-day experience of the student as the basis of a general survey of electrical applications. The result of combining with these experiences the lessons taught by scientific research, will be, Professor Norris believes, a clearer conception of electrical laws than can be obtained in any other way. The author's point of view is that a student should have intimate personal knowledge of the things and phenomena with which he has to deal before any explanation of the reasons why these

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phenomena take place is offered. As a result this work is of a descriptive character and one which can be understood by any intelligent young man before he has had any technical training. The book opens with an interesting historical survey of the development of electrical engineering. The next two chapters take up the fundamental electrical and magnetic units and materials. These are followed by two chapters on electric and magnetic circuits. The author then takes up the construction and operation of electric generators. Transformers and their application form the subject of the next chapter, which is followed by a discussion of the construction and operation of power plants. Electric motors and their application, electric lighting and heating, and electrical measurements are then taken up and the work closes with a chapter on the transmission of intelligence. In this the various systems of telegraphy and telephony are briefly considered. A very complete index adds considerably to the value of the book.

WATER SUPPLY.—By Frederick E. Turneaure, C. E., D. Eng., Dean of the College of Mechanics and Engineering, University of Wisconsin, Madison, Wis. Chicago: The American School of Correspondence. Cloth; 6½ × 9½ ins.; pp. 143; illustrated. $1.00.

This work is issued to supply the need felt for a practical working guide, of low cost, that will appeal not only to the technically trained man, but to the beginner and self-taught man as well. A special effort has therefore been made to have the language clear and simple, and the formulas of higher mathematics have not been included. The arrangement of the subject-matter is such as to carry the reader along from the easier steps until he gains complete mastery of the subject. The book opens with a discussion of water consumption and the sources of supply. The collection of supplies is then taken up and a section on distribution follows. A chapter on the purification of water closes the work. The book is a most excellent elementary summary of the fundamentals underlying the subject, and is altogether up to the high standard established by the author in the longer work on "Public Water Supplies" written by him in collaboration with H. L. Russell. One criticism might be made of the discussion on "Domestic Filters," which is given a very scanty treatment. This subject, which is a most important one in almost every community, is dismissed after a discussion covering about three-fourths of a page. This fault is not, however, peculiar to Prof. Turneaure's work, as almost every text-book on the subject of water supply is deficient in its treatment of this branch of the subject.

POWER AND TRANSMISSION.—By E. W. Kerr, M. E., Professor of Mechanical Engineering, Louisiana State University. Second Edition; Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xiv. + 366; 264 illustrations in the text. $2.

The fact that this work is now in its second edition indicates the favorable reception which it has had as an elementary text-book for use in colleges and technical schools. The book has been altered by the rewriting of the chapters on steam turbines and valve diagrams, and the addition of matter on heat and the use of the steam table. A large number of new problems have been added and errors which appeared in the first edition have been corrected. The work is divided into three parts, the first dealing with the general subjects of machinery and mechanics. This section contains chapters on shafting, bearings, friction and lubrication of bearings, friction wheels, pulleys, belt gearing, toothed wheels, screws, cams, levers, linkwork, and pipe fittings. The second part of the work deals with steam power in general, and is subdivided into chapters on heat and steam, the simple steam engine, automatic cut-off engines, high-speed engines, indicators, compound engines, condensers, valves and valve diagrams, rotary engines and steam turbines and appendages to engines. The third section covers the subjects of pumping machinery, gas-engines, water-power, compressed air and hot air engines. Tables in an appendix give the properties of steam, the flow of water over weirs, the flow of compressed air through pipes and the velocity of water.

DREDGING FOR GOLD IN CALIFORNIA.—By D'Arcy Weatherbe, M. C. S. C. E. San Francisco: The Mining and Scientific Press. Cloth; 6x9 ins.; pp. 219; with 103 illustrations in the text. $4.

Some of the matter which this work contains appeared in "The Mining and Scientific Press," but the greater part of it is new. It contains considerable matter which has been collected by the author on methods and costs of dredging work that will be of value to the mining engineer. The first chapter is devoted to in-

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troductory remarks and a discussion of the geology of the California gold fields. Chapter II deals with the methods to be employed in prospecting dredging ground, precautions to be observed, etc. In Chapter III the author treats of dredging machinery, and many illustrations of dredges at work are here given. The fourth chapter deals with the methods of operation, and in Chapter V the metallurgy of dredging is taken up. The next chapter discusses costs and the importance of lost time as a factor in increasing the expenses of the work is carefully shown. Chapter VII takes up the horticultural question and comparative profits obtained by dredging land for gold and using it for agricultural purposes are considered. Chapter VIII is devoted to general considerations, and in Chapter IX the opinions of a number of mining engineers on various phases of the subject in question are given. The illustrations and typography of the book are good.

WIRELESS TELEPHONY.—In Theory and Practice. By Ernst Ruhmer. Translated from the German by James Erskine-Murray, D. Sc., Fellow of the Royal Society of Edinburgh. New York: D. Van Nostrand & Co. London: Crosby Lockwood & Son. Cloth; 6 × 8½ ins.; pp. 217; illustrated. $3.50, net.

This work is the first published complete account of the progress that has been made in the field of wireless telephony. In view of this fact the author has avoided technicalities as far as possible, in order to make his work readable by all interested in this branch of electrical engineering. The book is well up to date, describing experiments made by the author as late as February, 1907, and others made by the translator in August of last year. The author first takes up the question of wireless telephony by means of light or heat radiation. In this section are six chapters, dealing with the photophone, varying sources of radiation, the speaking arc, the photographophone, light-telephony at useful distances, and the best working conditions for light-telephony. The second part of the book is devoted to the discussion of wireless telephony by means of electrical forces. The various chapters deal with the subjects of closed-circuit telephony, electromagnetic induction telephony, spark telephony, accelerated spark rates, multiphase spark discharges, high frequency alternators, the arc as a high frequency generator, the Poulsen generator, multiple arcs in air, applications of the arc to telephony, the Duddell phenomenon and forced vibrations. The author then gives his conclusions as to the usefulness of wireless telephony. This is followed by an appendix by the translator in which he describes briefly his own experiments in the United States. Altogether the work is undoubtedly the most complete presentation of the subject that is in print.

THE GAS ENGINE.—A Treatise on the Internal-Combustion Engine Using Gas, Gasoline, Kerosene, Alcohol, or other Hydrocarbon as Source of Energy. By Frederick Remsen Hutton, E. M., Ph. D., Sc. D. Third Edition, Revised and Enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xviii + 553; 250 text figures; $5.00.

The rapid progress in the design and construction of internal-combustion engines, which has been made in the last few years, has led the author of this standard work to bring it more thoroughly up to date. In the first two editions the author had prominently before his mind the idea of examining what the machine does and how this is accomplished. In this edition, on the other hand, he considers the gas-engine from the quantitative view-point more fully, that is, with the idea of examining the size it must have to do a certain amount of work in accordance with the limits sets by natural laws. In this connection the reference table of gaseous fuels is of particular value in connection with the determination of mean effective pressure. The treatment of this subject, as well as that of efficiency are new in this edition. The treatment of the question of the guarantee of efficiency and economy is also new, and the discussion of the producer, of the use of alcohol as a fuel, and of the carburetor have all been considerably expanded and brought down to date.

MOVING LOADS ON RAILWAY UNDER-BRIDGES.—Including Diagrams of Bending Moments and Shearing Forces and Tables of Equivalent Uniform Live Loads. By Harry Bamford, M. S., A. M. Inst. C. E., Lecturer on Engineering Drawing and Design, Glasgow University. London and New York: Whitaker & Co. Flexible cloth; 6½ × 8 ins.; pp. 78; illustrated with 80 text figures. $1.25, net.

Some years ago the writer's attention was directed to the tedious and unscientific methods which were then used for the preparation of tables for the "equivalent uniform live loads" for railway underline bridges. He conceived the idea that much of this labor could be saved and the work greatly simplified, by

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the direct application of the funicular polygon. After considerable work along this line he succeeded in devising a graphical method, whereby on a single diagram the maximum shears and the maximum bending moments and the points along the spans at which they occur, could be easily determined for a wide range of spans and for any given type of train. A description of this method appeared in "Engineering" (London). The matter thus published was collected and rewritten, and now forms four chapters of this work. Three other chapters on diagrams of bending moments and shearing forces in beams were added to make the work complete. Altogether it is a book that will be found useful by designers of railway underbridges and engineering students who are working on the subject.

THE GAS ENGINE IN PRINCIPLE AND PRACTICE.—By A. H. Goldingham, M. E. St. Joseph, Mich.: The Gas Power Publishing Co. Cloth; 6½ × 9½ ins.; pp. 195; 103 illustrations in the text; $1.50.

The publishers of this work have issued it with the idea of giving those who are interested in the internal combustion engine such information as will more readily enable such persons to comprehend their action and understand the advantages which may be derived from their use. In order that the readers who are not familiar with the subject may readily understand the work, the author has made it as simple as possible and in his treatment has avoided the use of mathematics as far as is practical. The matter has been compiled from articles which have appeared in "Gas Power" and from other sources. The work includes a general discussion of the various types of internal combustion engines, and the principles and practice of their operation. Various designs are described and a comparison of the two-cycle and four-cycle types is made. The author also takes up crude oil vaporizers and the suction and pressure types of gas producers are discussed.

STRUCTURAL DRAWING.—By C. Franklin Edminster, Instructor in the Department of Fine and Applied Arts, Pratt Institute, Brooklyn, N. Y. Published by the Author. (Supplied by David Williams Co., New York.) Cloth; 8¾ × 7¼ ins.; pp. 148; 74 illustrations, mostly in the text. $2.50.

The design of the author in preparing this work was to present a systematic course of instruction in structural drawing. The first chapter contains notes on the materials used, for the benefit of beginners. In the second chapter the author presents a number of simple problems in geometry and projection. Chapter III. takes up simple projection and the principles of working drawings are introduced. The last three chapters are devoted to the explanation of plates illustrating structural details, such as angles, Z-bars, nuts, anchors, rivets, etc., details of steel mill construction and iron staircase construction. The mechanical draftsman who may have, from time to time, structural drawing to do, as well as the student and mechanic interested in structural drawing, will find this work of value.

ELECTRICAL INSTRUMENTS AND TESTING.—By Norman H. Schneider. With New Chapters on Testing Wires and Cables and Locating Faults, by Jesse Hargrave, Assistant Electrical Engineer of the Postal Telegraph Cable Co. Third Edition, Revised and Considerably Enlarged, with 28 New Diagrams. New York: Spon & Chamberlain. London: E. & F. Spon, Ltd. Cloth: 5x7½ ins.; pp. 239, with 133 illustrations in the text. $1, net.

In this the third edition of Mr. Schneider's work on electrical instruments considerable new matter has been added and various revisions have been made to bring the book thoroughly up to date. Two new chapters on testing wires and cables by Mr. Jesse Hargrave have been added. The book is intended not as a treatise on electrical instruments but rather as a practical manual and as an introduction to more complete and theoretical works on the subject.

ENGINEERS' HANDBOOK OF CONCRETE REINFORCEMENT.—The American Steel & Wire Co., Chicago. Cloth; 6 × 9 ins.; p. 118; with many full-page, half-tone illustrations and diagrams. $2.

This is one of an increasing number of avowed trade publications, which are of marked value to engineers by reason of the compiled technical information which they contain. The present work contains a large amount of matter selected and reprinted by permission from some of the best known works on the subject, together with data obtained in practice by the company's engineers. The important features of the steel-wire mesh reinforcement made by the company are clearly set forth, and many illustrations are given showing work in various stages of progress.

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HOW TO READ PLANS.—By Charles G. Peker, editor of "The Wood Worker's Review." New York: The Industrial Publication Co. Cloth. 5 × 7½ ins.; pp. 46. Illustrated with 43 text figures and 8 large inserts of plans. Price 50 cents.

This little work is a simple practical explanation of the meaning of the various lines, marks, symbols and devices used on working drawings, so that they can be correctly followed by the workman. It is not a work for the engineer, but for the mechanic who is handicapped by a lack of technical knowledge and training. Employers who wish to recommend to such workmen a book which will enable them to understand and use plans, will find this work adapted to their purposes.

FOUR-YEAR TOPICAL INDEX TO THE ELECTRIC JOURNAL.—Pittsburg: The Electric Club. Paper; 6 × 9 ins.; pp. 30; 25 cents.

This index contains a list of all the important articles which have appeared in "The Electric Journal" since the first issue. The index is arranged under topics, so that any one who wishes references to one subject may find everything which has appeared in the magazine on that subject in convenient form. In addition to this topical index an authors' index is also given. One feature of the index which deserves spécial recommendation is the fact that it is printed on but one side of the page, thus allowing it to be cut up for use in a card index.

NEW BOOKS.

Civil Engineering.

HANDBUCH FUER EISENTONBAU.—Edited by F. von Emperger. Vol. II.: The Material and Its Manipulation. Prepared by K. Memmler, H. Buchartz, H. Albrecht, R. Janesch, O. Rappold, A. Nowak. Berlin, Germany: Wilhelm Ernst & Sohn. Paper; 7¼ × 10½ ins.; pp. 243; 420 text illustrations and 1 folding plate. 12 marks; American price, $4.80.

THE DESIGN OF TYPICAL STEEL RAILWAY BRIDGES.—An Elementary Course for Engineering Students and Draftsmen. By W. Chase Thomson, M. Can. Soc. C. E., Assistant Engineer, Dominion Bridge Co., Ltd., Montreal. Author of "Bridge and Structural Design." New York: The Engineering News Publishing Co. Cloth; 6 × 9 ins.; pp. vii. + 178; 21 diagrams and detail drawings (including 5 folding plates). $2, net.

THE ELEMENTS OF RAILROAD ENGINEERING.—Railroad Engineering, Vol. II. By William G. Raymond, C. E., LL. D., Professor of Civil Engineering and Dean of the College of Applied Science, the State University of Iowa. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xvi. + 405; 107 figures and 18 plates. $3.50 net.

Mechanical Engineering.

ELEVATOR SERVICE.—By Reginald Pelham Bolton, M. Am. Soc. M. E., Author of "Motive Powers and Their Practical Selection." Operating Conditions and Proportions, with Diagrams, Formulas, and Tables for Passenger Travel, Schedule and Express Operation, with the Relation of the Elevators to the Building, and Proportions and Loads of Cars. New York: The author (527 Fifth Ave.). Cloth; 7½ × 11 ins.; pp. 69; folding and other diagrams. $5, net.

GAS-POWER.—A Study of the Evolution of Gas Power, the Design and Construction of Large Gas Engines in Europe, the Application of Gas Power to Various Industries and the Rational Utilization of Low Grade Fuels. By F. E. Yunge, M. A., C. E., M. E., Member Verein Deutscher Ingenieure. New York and London: Hill Publishing Co. Cloth; 6 × 9¼ ins.; pp. 548; 8 plates and 159 text illustrations. $5.

PRACTICAL CALCULATIONS FOR ENGINEERS.—For the Use of Engineering Students, Apprentices, Draftsmen, Mechanics, Foremen, and Others Practically Engaged in Engineering Work. By C. E. Larard, M. Inst. M. E., etc., Head of the Mechanical Engineering Department at the Northampton Institute, London, E. C., and H. A. Golding, Assoc. M. Inst. M. E. London, England: Charles Griffin & Co., Ltd. Philadelphia, Pa.: J. B. Lippincott Co. Cloth; 5 × 7¾ ins.; pp. 455; 212 illustrations, mostly in the text. $2, net.

STATIONARY STEAM ENGINES.—Illustrated with Numerous Examples from Actual Practice. Edited by William H. Fowler, M. Inst. C. E., M. Inst. M. E., etc. Manchester, England: The Scientific Publishing Co. Cloth; 7¼ × 10 ins.; pp. 299; 326 illustrations in the text. 12s., 6d., net; American price, $5.

Mining Engineering.

MINING, MINERAL AND GEOLOGICAL LAW.—A Treatise on the Law of the United States Involving Geology, Mineralogy and Allied Sciences as Applied in Mining, Real Estate, Public Land, United States Customs and Other Litigation, Also the Acquisition and Maintenance of Mining Rights in the Public Domain and Obtaining Patents for Mineral Land Under the United States Mining Laws. By Charles H. Shamel, Ph.D., of the Illinois and Michigan Bars. London and New York: Hill Publishing Co. Cloth; 6 × 9½ ins.; pp. 627; 103 illustrations in the text and 1 folding sheet. $5.

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Railway Engineering.

OBERBAU UND GLEISVERBINDUNGEN.—Section 2, Part II. (Der Eisenbahn-Bau der Gegenwart), Die Eisenbahn-Technik der Gegenwart. Prepared by A. Blum, Berlin; Schubert, Berlin; Himbeck, Berlin; Fraenkel, Tempelhof. Second Edition, enlarged. Wiesbaden, Germany: C. W. Kreidel. Paper; 7¼ × 11 ins.; pp. 145 to 459; 2 plates and 140 text illustrations. 12 marks; American price, $4.80.

Sanitary Engineering.

SIGNIFICANCE OF THE NUMBERS OF BACTERIA IN WATER AND SEWAGE DEVELOPING AT DIFFERENT TEMPERATURES.—By Stephen DeM. Gage, Biologist at the Lawrence Experiment Station. (Reprinted from the 38th Annual Report of the Massachusetts State Board of Health, 1906, pp. 325 to 349.) Paper; 5¾ × 9¼ ins.; pp. 25; 15 tables.

Miscellaneous.

AMERICAN RAILWAYS AS INVESTMENTS.—A Detailed and Comparative Analysis of All the Leading Railways from the Investor's Point of View; With an Introductory Chapter on The Methods of Estimating Railway Values. By Carl Snyder. New York: The Moody Corporation. London, England: Frederic C. Mathieson & Sons. Cloth; 6¼ × 9½ ins.; pp. 762; one folding map. $3.20. net; by mail, $3.40.

CONTRACTS AND SPECIFICATIONS.—A Working Manual of Correct Forms Covering the Relations of Architect, Contractor and Owner, Methods of Awarding and Executing Public and Private Contracts, and Instruction in the Art of Specification Writing. Part I., by James C. Plant, Superintendent of Computing Division, Office of Supervising Architect, U. S. Treasury Department, Washington, D. C. Part II., Edited by Alfred E. Zapf, Secretary American School of Correspondence, Chicago, Ill. Chicago, Ill.: American School of Correspondence. Cloth; 6½ × 9¾ ins.; pp. 112; plates and text illustrations. $1.

ENGINEERING REMINISCENCES, 1855-1882.—By Charles T. Porter. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xii. + 335; 52 illustrations and 38 full-page portraits. $3, net.

POOR'S MANUAL OF THE RAILROADS OF THE UNITED STATES.—Street Railway and Traction Companies, Industrial and Other Corporations. 40th Annual Number, 1907. New York: Poor's Railroad Manual Co. London, England: Effingham Wilson. Cloth; 6 × 9 ins.; pp. 108 + xvi. + 1,774; folding and other plates. $10.

THE SCIENCE YEAR BOOK.—With Astronomical, Physical and Chemical Tables, Summary of Progress in Science, Directory, Biographies, and Diary for 1908. (Fourth Year of Issue.) Edited by Major B. F. S. Baden-Powell. London, England: King, Sell & Olding, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 153 + 365; illustrated. 5s., net; American price, $2.

The American Society of Mechanical Engineers, with the desire to develop their publications still further, have been fortunate in securing Mr. Lester G. French to direct their editorial department. Among the immediate improvements to be undertaken is the establishing of departments in the monthly Proceedings, thus providing a greater variety of technical articles. Other features are planned and the aim will be to make the Proceedings of far greater value than in the past. All papers, however, will be presented and discussed before the Society at its meetings as formerly. Mr. French was born in Keene, New Hampshire, in 1869, and early commenced his training in editorial work and printing at Brattleboro, Vt., his father having been for a long time the publisher of "The Vermont Phoenix," and a partner in a large printing establishment there. In 1891, Mr. French received his degree in mechanical engineering from the Massachusetts Institute of Technology. After four years' experience, principally in the shops of the Builders' Iron Foundry in Providence, and a year and a half as a text-book writer, Mr. French was engaged on the editorial staff of "Machinery," and for nine years was its editor-in-chief. Recently Mr. French was engaged in the publishing of technical books.

"Hardware," a magazine devoted to the interests of that trade, has recently secured offices at 114 Liberty street, New York, and will in the future be published from that office. The company issuing it was formerly known as The Hardware Publishing Co., but will in the future bear the name of The Hardware Press. The president of the company is Mr. Harold S. Buttenheim, formerly secretary of The McGraw Publishing Co. Mr. Buttenheim has had fifteen years' experience with trade and technical journals, his recent duties with The McGraw Co. including the business management of the Street Railway Journal, and a supervision of the circulation department of that paper and those of the "Electrical World" and "The Engineering Record."

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hanger is thus obviated. The fans may be made either right or left hand or inverted without reference to the bearings, for which special oiling arrangements would be required in other types. The same hanger is used on both single and double exhausters.

Comparative tests definitely prove the superiority of the ball bearing fan over one fitted with plain babbitted bearings. A summary of such tests shows a decrease of about 10% in the requirement below that necessary with the older type. To provide against misleading results in these tests both fans were previously run for several weeks, so that they presented ordinary conditions. Such economy in favor of the ball bearing fan shows an approximate annual saving of 25% of the purchase price of the fan.

The convertible type with bearings formed in the hanger and with overhung wheel is made in sizes up to and including 60-inch diameter of shell. In larger sizes the ordinary form of casing construction is employed and the bearings are of necessity constructed as independent boxes to be bolted on to the supports. In the larger fans the bearings contain two ball races instead of one, as in the case of the smaller sizes. Two case hardened cups are forced back to back into a circular containing ring; a sleeve is placed at the middle, and upon each end is forced a case hardened one. The whole, including balls, is held on a pivot center of the ball and socket type by which self-alignment is secured. The bearings, each of which is entirely independent of the fan, are bolted to cross bars, supported by angle iron uprights, both securely riveted to the fan sheet. The fan shaft is slipped through the sleeve. In both types the balls are thoroughly protected from dust by easily removable washers. There is no leakage of oil, no pollution of air by odors of heated oil and no soiling of surfaces with which the oil may come in contact. The fire risk incident to dripping bearings and collected lint is entirely obviated. The fact that a well-tried type of bearing of established standing has been adopted insures freedom from the troubles often common to the somewhat experimental stage of development of a new design.

Williams Bros., of Ithaca, N. Y., the well-known manufacturers of drilling machinery, have just issued a catalog which describes over seventy styles and sizes of machines for drilling deep and shallow wells in any kind of soil or rock.

A NEW COMPOUND FOR WATERPROOFING CONCRETE.

Despite its popularity and wide application as a building material, concrete has one fault —its tendency to "soak." One of the great dangers in reinforced concrete construction is that arising from the permeability of the concrete. Because of this absorbent quality, water can readily find its way to steel embedded in the concrete and there begin the work of corrosion. The consequence of this corrosion is not only a weakening of the steel but the actual disruption of the concrete itself, since the rusting of the steel will cause an increase in volume and when the stresses become great enough the concrete will be burst.

A simple, effective and economical method for obtaining a dry concrete is to add an efficient waterproofing compound to the mixture, or to provide a cement mortar which will serve as a waterproof facing. The high degree of efficiency to which a waterproofing compound of this nature may be brought when developed along scientific lines is exemplified in the Hydratite compound, manufactured by the A. C. Horn Company, 6-8 Burling Slip, New York City, which is probably the most improved method of cement waterproofing yet offered to the public. Hydratite accomplishes the waterproofing of concrete by acting chemically on the constituents of the body into which it enters. By this chemical activity it becomes an integral part of the mass and the water-resisting qualities which it infuses into the mass do not last merely for a short time, but as long as the material itself. Furthermore, it does not affect the strengh of the concrete nor its final setting.

Some of the uses to which Hydratite may be put are the following: for waterproofing reinforced concrete work, concrete reservoirs, swimming pools, floors, sub-structural work and concrete blocks. It is also of great value in repairing leaky walls and waterproofing stucco fronts.

Several months ago a number of men, then associated with the G. & H. Barnett Co., of Philadelphia, formed the Carver File Co. The company has now a large factory in that city and is manufacturing files at the rate of one thousand dozen per day. The company has already established a reputation for the high grade of its product, and the careful manner in which its files are made, together with the exercise of the most competent judgment in the selection of material, enables it to com-

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pete with the largest manufacturers, both in respect to quality and price. The most improved labor-saving devices and machines have been installed in the company's large factory and this equipment, together with the personality of the officials, insures the continuance of the high standard of quality already set by the concern.

A DEVICE FOR THE DETECTION OF FIRE.

The importance of instant fire alarm cannot be overestimated; in fact, only one service can exceed it in value—that which forewarns of the approach of fire, that gives notice that temperature is rising dangerously near the point of ignition. The latter service is that which the thermostat is expected to render; unfortunately, it does not always fulfil expectations, and for these reasons. Placed in accordance with the underwriters' rules, twelve feet apart, the air currents may carry the heat waves between, and not bring them in contact with, the thermostats, many of which have faults inherent in their mechanism and construction. Some of these devices depend for contact on the expansion of a spring, which may get out of adjustment and cause the device to either send a false alarm or—worse yet—no alarm at all. Some are insufficiently protected against the intrusion of dust, vermin or insects, against moisture, or against corrosion

MONTAUK FIRE DETECTING WIRE

from acids—all of which tend to render them ineffective. Those that depend on a pinpoint contact, which must be absolutely perfect to close the circuit, may fail through insulation by the interposition of a little dust or dirt. Some are adversely affected by the alternate heating and cooling of the surrounding atmosphere; others may be so disturbed by even slight shocks as to render them inoperative.

After much study and experimental work, the Montauk Fire-Detecting Wire Co., of 100 William Street, New York City, have perfected a device for discovering and forewarning of fire, which is shown by the accompanying illustration. The core wire (aa), the first conductor, is encased in the fusible metal (bb), which, in turn, is covered with the insulating material (cc), the whole contained in a copper tube (d), which constitutes the second conductor, and is the size of an ordinary telegraph wire. Any and every part of the wire's surface is a thoroughly reliable thermostat, whether the wire be inches or miles in length; it can, moreover, be installed as an annunciating wire, and thus made to perform a dual service, saving in this way no little expense. When used for bell wire a practical local fire alarm service is also obtained; a comprehensive one if it be extended to all danger points, and effective on land or sea.

The wires at present being made by the company are the standards, those which will be set off at 160, 200 and 370° F., all thermometrical points considerably above normal heat, and yet well below the point of ignition. When the temperature rises to the degree at which the wire is designed to operate, a circuit is instantly established, the heat softens and expands the fusible metal, which, forced through the meshes of the insulation and against the inner surface of the copper tube, forms contact between the latter and the core wire, and soldering, seals the contact permanently, thus causing all connected bells to ring and to continue ringing as long as the battery lasts, or until switched off.

The Montauk is said to be the only continuous thermostat, the only one that can be installed in water, and the only one that will withstand illegitimate abuse. That it can withstand extraordinary abuse is certainly true, for hammering it violently enough to imbed it in hard wood will not put it out of order. It can be placed on ceilings, as demanded by the underwriters, and also in many places where the ordinary thermostat cannot; for example, as a girdle around wainscoting in coal bunkers, near ash bins, in elevator shafts, and, in fact, in every place where the fire hazard would suggest its installation. As an evidence of the various uses to which the Montauk fire-detecting wire can be put, it may be said that a low-degree wire is used by the telephone companies, in connection with their switchboard wires, to indicate rising temperature.

Thermostats are also made by this company, consisting of a short piece of the detecting wire attached to terminals and mounted on porcelain bases. These have all of the advantages that any form of thermostat can possess, and, in addition, the positive and unfailing qualities embodied in the wire itself. This wire has been installed in a large number of residences, theatres, clubs and office buildings; also in the United States Government Immigration Station at Ellis Island, and in the Brooklyn Navy Yard, for use on United States Government warships.

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Believing that there is a field for an illustrating company to do work of a technical nature exclusively, a number of gentlemen have recently formed in Scranton, Pa., a company to do work of this kind. The company is making efforts to get in touch with authors who are contemplating publishing technical works in order to provide neat and clear illustrations for these works, and also aims to get into touch with publishers of technical works who have not a corps of illustrators of their own. It will also undertake to illustrate catalogues of engineering firms, as well as pamphlets and circulars sent out to further the sale of machinery, etc. The company is well equipped to handle any large or small contracts for illustrating such publications as have been mentioned, and will undoubtedly fill a field that has long been vacant.—From literature of the Technical Illustrating Co., Box 365, Scranton, Pa.

TRADE PUBLICATIONS.

STAMPED STEEL OUTLET BOXES AND FITTINGS.—Circular No. 428 of the Sprague Electric Co., 527 West 34th St., New York. Paper; 3½ × 6 ins.; pp. 8; illustrated.

In this folder several types of switch and box covers, steel outlet box connectors, and panel box connectors, all of which are made from one piece of sheet steel, are illustrated and their retail prices quoted.

A REPORT ON SANITARY SEWERS.—By Charles Cottingham, C. E., Danville, Ill. Paper, 3½ × 6 ins.; pp. 16.

This interesting booklet contains the report made by Mr. Cottingham to the Mayor and Council of Hoopestown, Ill. General recommendations are contained in the report regarding the construction of an adequate and efficient system of sewage disposal for small cities.

INTERLOCKING STEEL SHEETING.—Geo. W. Jackson, Inc., 46 Wall St., New York. Paper; 10 × 7 ins.; pp. 72; illustrated.

The many and varied uses of the interlocking steel sheeting made by this company are illustrated in this pamphlet. This sheeting may be used for cofferdams, piles, water-tight casings, bridge foundations, piles and casings for building foundations, construction of locks, foundations for light-houses, dry docks, etc.

UNDERGROUND CONDUIT CONSTRUCTION.—American Conduit Co., 140 Nassau St., New York City. Paper; 3½ × 6¾ ins.; pp. 32; illustrated.

This pamphlet describes the bitumenized fiber conduit used by the American Conduit Co. in constructing underground conduits. The advantages which it possesses over iron pipe are shown, and the methods used by the company in laying the conduits are illustrated.

LIFTING MAGNETS.—The Electric Controller & Supply Co., Cleveland, O. Paper; 8 × 10¾ ins.; pp. 32; illustrated.

Ten years ago the use of magnets in industrial work for the handling of material was unknown. An idea of their wide range of application may be gained from this catalog, which describes magnets manufactured by the Electric Controller & Supply Company and the different places in which they may be used.

ELECTRIC HOISTING ENGINES.—Lidgerwood Mfg. Co., 96 Liberty St., New York. Paper; 9 × 11¾ ins.; pp. 8; illustrated.

The circular describes the line of direct current electric hoists furnished by the company. They are made with single or double friction drums, and operate at 250-500 volts. They are self-contained, with motor, controller, resistances and drums, all mounted on one bedplate, and are readily portable. The single-drum hoists are made in sizes ranging from ¼ to 50 HP., and the double-drum from 15 to 50 HP. A 20-HP. electric mast hoist is also listed, which has a nominal capacity of 4,000 lbs. at a speed of 130 ft. per min.

THE MILLIONAIRE.—W. A. Morschhauser, 1 Madison Ave., New York City. 9 × 5½ ins.; pp. 16; illustrated.

The "Millionaire" calculating machine is described and illustrated in this pamphlet. It is adapted for working all kinds of calculations which can be made by addition, subtraction, multiplication or division. The accuracy, simplicity and speed of the machine are its best recommendations. Several machines are illustrated, one of which has a capacity up to twenty figures.

THE CONARD SYSTEM OF STRUCTURALLY REINFORCED CONCRETE.—A Fireproof Structure Strong and Reliable as Structural Steel and Cheaper than Wood. W. W. Conard, C. E., Norristown, Pa. Paper; 6 × 9 ins.; pp. 32; illustrated.

Mr. W. W. Conard, the patentee of the Conard System, in this booklet outlines the advantages which it is said to possess over other types of reinforced concrete construction. The design of beams and girders in this system is thoroughly explained and examples of types are worked out. A number of tables of bending moments are also given.

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THE

TECHNICAL PRESS INDEX

220 BROADWAY, NEW YORK

This Index is intended to cover the field of technical literature in a manner that will make it of the greatest use to the greatest number—that is, it will endeavor to list all the articles and comment of technical value appearing in current periodicals. Its arrangement has been made with the view to its adaptability for a card-index, which engineers, architects and other technical men are gradually coming to consider as an indispensable adjunct of their offices.

Each item gives:

1. Full title and author.
2. Name and date of publication.
3. An estimate of length of article.
4. A short descriptive note regarding the scope of the article—where considered necessary.
5. Price at which we can supply current articles.

The Publishers do not carry copies of any of these articles in stock, but, if desired, will supply copies of the periodical containing the article at the prices mentioned. Any premium asked for out-of-date copies must be added to this price.

The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

In order to comply with the many suggestions and requests of readers who desire to make practical use of this index, it is printed on one side of the sheet only, to permit the clipping of any desired items.

LIST OF PERIODICALS INDEXED

JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

Journal Am. Foundrymen's Assn.
Journal Assoc. Engineering Societies.
Journal Eng. Soc. of Western Pa.
Journal Franklin Institute.
Journal West. Society of Engineers.
Proceedings Am. Soc. C. E.
Proceedings Am. Soc. M. E.
Proceedings Can. Soc. C. E.
Proceedings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
Proceedings Pacific Coast Ry. Club.
Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
Transactions Am. Inst. Electrical Engineers.
Transactions Am. Inst. Mining Engineers.

(Continued on second page following.)

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TECHNICAL PERIODICALS

An inch card under this heading costs $2.50 a month

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Cement Age.
Cement and Engineering News.
Cement Era.
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Commercial America.
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Concrete.
Concrete Age.
Concrete Engineering.
Contractor.
Cornell Civil Engineer.
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Domestic Engineering.
Economic Geology.
Electrical Age.
Electrical Review.
Electric Journal.
Electric Railway Review.—See Adv. opposite.
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Iron Trade Review.
Irrigation Age.
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Journal of Worcester Polytechnic Institute
Judicious Advertising.
Machinery.
Marine Review.
Metal Industry.
Metal Worker, Plumber and Steam Fitter.
Mines and Minerals.
Mines and Mining.
Mining and Scientific Press.
Mining Science.
Mining World.
Modern Machinery.
Moody's Magazine.
Motor.
Motor Age.
Motor Boat.
Motor Car.
Motor Traffic.
Municipal Engineering.
Municipal Journal and Engineer.
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Plumber's Trade Journal.
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Popular Science Monthly.
Power.
Power and Transmission.
Power Wagon.
Printers' Ink.
Profitable Advertising.
Progressive Age.—See Adv. opposite.
Railroad Gazette.
Railway Age.—See Adv. opposite.
Railway and Engineering Review.
Railway and Locomotive Engineering.
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Railway Master Mechanic.
Roadmaster and Foreman.—See Adv. opposite.
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Scientific American.
Scientific American Supplement.
Selling Magazine.
Sibley Journal of Engineering.
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Minero Mexicano. (w.) Mexico.
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Schweizerische Bauzeitung. (w.) Zurich.
Stahl und Eisen. (w.) Düsseldorf.
Technique Sanitaire. (m.) Paris.
Zeitschrift für Bauwesen. (q.) Berlin.
Zeitschrift f. d. Gesamte Turbinenwesen. (w.) Munich.
Zeitschrift d. Oest. Ing. und Arch. Ver. (w.) Vienna.
Zeitschrift d. Ver Deutscher Ing. (w.) Berlin.
Zeitschrift für Elektrochemie. (w.) Halle a/S.
Zentralblatt d. Bauverwaltung. (s-w.) Berlin.

Index to Articles begins on Second Page Following.

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INDEX TO ARTICLES

ARCHITECTURE.

For Steel and Reinforced Concrete Building Construction, Foundations, Masonry, etc., see "Engineering Construction and Materials" under CIVIL ENGINEERING; for Heating and Ventilation, see subdivision similarly entitled under MECHANICAL ENGINEERING; for Electric Lighting, see "Lighting" under ELECTRICAL ENGINEERING; for Elevators, see "Hoisting and Handling Machinery" under MECHANICAL ENGINEERING; for Plumbing and Sanitation, see "Sewerage" under MUNICIPAL ENGINEERING.

Church Building.

The Building of the Church. J. A. Schweinfurth. Am Arch—Feb 26, 08. 21 figs. 5000 w. An article supplemented by many exterior and interior views of American and European edifices, the entire number being devoted to the subject.

Public Schools.

Public School Building in the City of New York.—III. Am Arch—Mar 4, 08. 20 figs. 1000 w. 60c.

AUTOMOBILES AND AERIAL NAVIGATION.

Aeroplane Design.

The Problem of Flight. Engg—Feb 14, 08. 1800 w. 40c. Editorial on Farman's recent work, also discussing certain formulas for aeroplane design proposed by Capt. Ferber.

Alcohol Fuel.

Alcohol as a Motor-Car Fuel. P. S. Tice. Motor—Mar, 08. 3000 w. 20c.

Anti-Freezing Mixture.

The Behavior of Glycerine in Radiators. Com Motor—Feb 20, 08. 1 fig. 800 w. 40c. Gives the properties of a clean and reliable anti-freezing mixture containing 20% glycerine.

Front-Wheel Driving.

The Front Driving of Motor Cars. H. S. Hele-Shaw. Prac Engr—Feb 28, 08. 5 figs. 2900 w. 40c. Abstract of paper read Jan 20, 08, before the Institute of Automobile Engineers.

Garage and Generating Station.

Generating Station, Garage and Equipment of the Auto Transit Company of Philadelphia, Pa. El Wld—Feb 22, 08. 11 figs. 2000 w. 20c.

Hub Ball Bearings.

Automobile Hub Ball Bearings. Henry Hess. Automobile—Mar 5, 08. 7 figs. 2000 w. 20c. Paper read before the Society of Automobile Engineers.

Igniters.

Methods of Testing Igniting Apparatus.—II. F. W. Springer. El Wld—Feb 22, 08. 2 figs. 4600 w. 20c.

Motor-Car Frames, Bracing of.

The Bracing of Motor-Car Frames. Engg—Feb 21, 08. 6 figs. 3000 w. 40c.

Repairing Automobiles.

Problems in the Repairing of Automobiles. Automobile—Feb 20, 08. 7 figs. 3500 w. Feb 27, 11 figs. 1300 w. Each 20c. Emphasizes the importance of using good materials in repair work and discusses the qualities of nickel steel

CIVIL ENGINEERING

BRIDGES.

Arches.

A Defence of the Elastic Theory of Arch Analysis and a Caution. Wm. Cain. Eng News—Feb 27, 08. 1300 w. 20c. A reply to objections recently made.

Symmetrical Masonry Arches. Malverd A. Howe. R R Gaz—Mar 13, 08. 4 figs. 3500 w. 30c. Gives formulas for and describes the application of the summation method for determining horizontal thrust, bending moments at support, etc.

Bascule Bridges.

Rolling-Lift Bascule Bridge for the Baltimore & Ohio Ry. at Cleveland, Ohio. Eng News—Mar 12, 08. 2 figs. 1000 w. 20c. Describes a single-leaf, single-track structure of the Scherzer type, with a span of 230 ft. c. to c. of bearings.

The Bascule Bridge Between Portsmouth and Tiverton, R. I. Eng Rec—Feb 29, 08. 12 figs. 3000 w. 20c.

Bridge Floors.

Standard Overhead Bridge Floors, Philadelphia. Eng Rec—Mar 7, 08. 5 figs. 1300 w. 20c.

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Methods and Cost of Constructing Six Crib Piers., Three Howe Truss Spans and One Steel Draw Span. Rdmaster & Fore—Mar, 08. 2400 w. 20c.

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Latticing vs. Pin Connections.

Riveted Lattice or Pin-Connection for Railroad Bridges, An Answer to the Lattice Argument. C. A. P. Turner. Eng News—Feb 27, 08. 3400 w. 20c.

Lacing Compression Members.

The Lacing of Compression Members. Clyde I. Morris. Eng News—Feb 27, 08. 1 fig. 2000 w. 20c. Mathematical communication giving reason for assumptions made in a previous letter on the subject.

The Latticing Requirements of Built-up Steel Columns. F. Von Emperger. Beton u Eisen—Feb 19, 08. 1 fig. 2500 w. $1.00.

Quebec Bridge.

Finding of the Canadian Commission on the Quebec Bridge. Eng News—Mar 12, 08. 1400 w. 20c.

Reinforced Concrete Bridges.

Cost of Concrete Highway Bridges and Culverts in Greene County, Iowa. Eng Contr—Mar 4, 08. 900 w. 20c.

Ferro-Concrete Highway Bridges. Surveyor—Feb 7, 08. 15 figs. 1900 w. 40c. An illustrated description of some recent examples in Great Britain.

Method and Cost of Molding Large Concrete Slabs for Girder Bridges. Rdmaster & Fore—Mar, 08. 2 figs. 900 w. 20c.

Reinforced Concrete Bridge. A. F. Wells. Can Engr—Mar 6, 08. 3 figs. 1200 w. 20c. Describes highway bridge of 30-ft. span.

Some Reinforced Concrete Bridges in Italy. Con & Constr Eng—Mar, 08. 5 figs. 1700 w. 60c. Illustrates some excellent examples of Italian reinforced concrete bridge work constructed by Sig. Leonardi, of Milan.

The Wagaraw Bridge at Paterson. Eng Rec—Mar 7, 08. 3 figs. 1000 w. 20c. Describes a new three-span reinforced-concrete structure, 320 ft. long, over the Passaic River.

Swing Bridge.

New Swing Bridge Over the River Hull at Sculcoates, Hull. Engg—Feb 21, 08. 4 figs. 1500 w. 40c. Concluded.

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The Cost of Digging Some 600 Trolley Pole Holes. Eng Contr—Mar 4, 08. 3 figs. 1900 w. 20c.

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Building a Railway Embankment by the Hydraulic Method. Geo. H. Moore. Eng News—Mar 12, 08. 2 figs. 1300 w. 20c. Describes method used on a 750,000-cu. yd. embankment in Washington.

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Storage Bins for a German Plaster Works. R. Von Terzaghi. Beton u Eisen—Feb 19, 08. 12 figs. 2000 w. $1.00. Gives details and calculations used in the design.

Buildings.

A Cement Storage House with Separately Molded Reinforced-Concrete Members. Eng News—Feb 20, 08. 1700 w. 20c. Gives costs of manufacturing and erecting the columns, girder and roof slabs.

A Reinforced-Concrete Building with Concrete Domes; Cincinnati Zoological Garden. Eng News—Feb 20, 08. 5 figs. 1500 w. 20c. Describes an interesting example of the use of reinforced concrete for structures of a light and ornamental character.

Costs on a Reinforced-Concrete Factory Building. Eng News—Mar 5, 08. 400 w. 20c. Gives the itemized cost of a reinforced-concrete factory building recently erected in Walkerville, Ont.

Fireproof Storage Warehouse. Joseph B. Baker. Ins Engg—Mar, 08. 5 figs. 2200 w. 40c. Describes the building of the Security Storage Company of Washington, D. C.—built in units at different times, the units having independent walls and designed with the idea of localizing losses from fires.

Reinforced Concrete Construction in Butler Bros.' New Building. E. W. Maxton. Con Engg—Feb, 08. 4 figs. 2500 w. 20c. Concluded.

Structural Steel. Ernest G. Beck. Mech Wld—Feb 14, 08. 3 figs. 2000 w. 40c. II. Riveted Work (Continued).

Structural Steel Details of the Brooklyn Academy of Music. Eng Rec—Feb 22, 08. 16 figs. 2500 w. 20c.

The New Steel Warehouse Plant of the Carnegie Steel Co., at Waverly, N. J. Ir Tr Rev—Feb 20, 08. 9 figs. 3200 w. 20c.

The Reinforced Concrete Work of the McGraw Building. T. L. Condron and F. F.

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Sinks, E. W. Stern, L. J. Mensch and P. E. Stevens. Proc Am Soc C E—Feb, 08. 17 figs. 7000 w. 80c. Discussion continued from Jan, 1908, Proceedings.

Two Building Types Tested by Fire. Cement Age—Feb, 08. 4 figs. 1000 w. 20c. Gives a contrast between two structures recently destroyed by fire in New York City, which shows the superiority of concrete as a fire-resisting material.

Caisson Disease.

Caisson Disease. Engr (Lond)—Feb 14, 08. 2000 w. 40c. Gives a summary of a memorandum appearing in a recent report of the British Admiralty.

Chimneys, Heat Stresses in.

Heat Expansion Stresses in Chimneys. Eng News—Mar 5, 08. 1000 w. 20c. Gives formulas for calculating the temperature stresses in chimneys.

Dams.

Electrically Operated Sluice Gates and Drop-Timber Regulator Gates for the Laguna Dam. F. W. Hanna. Eng News—Feb 27, 08. 4 figs. 3000 w. 20c.

Structural Steel Dams. F. H. Bainbridge. Ind Mag—Feb, 08. 9 figs. 4500 w. 40c. Describes a number of structures and gives methods of design, etc.

The Construction of the Laguna Dam, Colorado River, Arizona. Edwin D. Vincent. Eng News—Feb 27, 08. 4 figs. 2200 w. 20c. Describes the construction of the dam, which is the key to Yuma project for the irrigation of some 90,000 acres of land.

The Raising of the Assuan Dam. Engr (Lond)—Feb 21, 08. 1600 w. 40c. Discusses the heightening of this dam, now in progress.

Foundations.

A Steel Pile Foundation in a Quicksand Pocket. Eng Rec—Feb 22, 08. 1300 w. 20c. Describes construction used for a 16-story building in New York City.

Defective Foundation at Mt. Royal Water Works Pumping Station, Baltimore, Md. Alfred M. Quick. Eng News—Mar 12, 08. 5 figs. 5000 w. 20c.

Loading Test of a "Compressol" Foundation Pile. F. Von Emperger. Beton u Eisen—Feb 19, 08. 8 figs. 5000 w. $1.00.

Small Piles for Underpinning Buildings. Eng Rec—Feb 29, 08. 400 w. 20c.

Some Lessons from a Cofferdam. W. H. Boughton. Eng Rec—Feb 29, 08. 1400 w. 20c. Paper read before the Ohio Engineering Society.

Underpinning Buildings Adjacent to the Bridge Loop Subway, New York. Eng Rec—Mar 7, 08. 1 fig. 2100 w. 20c.

Grain Elevator.

Mammoth Reinforced-Concrete Grain Elevator in Minneapolis, Minn. Conc—Mar, 08. 800 w. 20c.

Pipe Laying Costs.

The Cost of Laying 6 and 8-in. Wrought-Iron Screw-Joint Pipe. E. E. Harper. Eng News. Feb 27, 08. 2 figs. 1700 w. 20c.

Reinforced Concrete Construction.

Adjustable and Portable Forms for Concrete Building Construction. Eng News—Mar 5, 08. 4 figs. 7000 w. 20c.

A Hoist for Feeding Material to the Concrete Mixer. Eng News—Mar 5, 08. 2 figs. 1100 w. 20c.

A Practical System for Reinforcing Concrete. H. F. Porter. Can Engr—Mar 6, 08. 4 figs. 2900 w. 20c. Describes a system using plain reinforcing bars and providing for continuity.

A Traveling Mold for Making Reinforced-Concrete Pipe. F. Teichman. Eng News—Feb 20, 08. 4 figs. 2400 w. 20c. Describes molds for a 5-ft. pipe used by the U. S. Reclamation Service on the Salt River Project, Ariz.

Calculation for Reinforced Concrete Construction. R. Wuczkowski. Beton u Eisen—Feb 19, 08. 5 figs. 2500 w. $1.00. Gives a simple formula for use on rectangular and T-section beams.

Concrete Shop Construction with Separately Molded Members. Eng Rec—Feb 29, 08. 6 figs. 3100 w. 20c.

Cracks in Reinforced-Concrete Beams. F. Von Emperger. Zeit d Bau—Mar 4, 08. 8 figs. 3000 w. 40c. Graphical discussion.

Economical Design of Reinforced Concrete Beams. Elie Cannes. Eng Rec—Mar 7, 08. 2 figs. 1200 w. 20c. Gives diagrams showing what percentage of reinforcement will give the least expensive reinforced concrete beam under given conditions of cost of concrete and steel.

Graphic Design for Reinforcing Rectangular Concrete Sections. R. S. Peotter. Cem Age—Feb, 08. 4 figs. 3000 w. 20c. Gives a condensed analysis of the subject and graphs of results on logarithmic cross-section paper.

Graphostatic Calculations for Reinforced Concrete Constructions. G. Ramisch. Beton u Eisen—Feb 19, 08. 4 figs. 4000 w. $1.00. Gives mathematical relations and graphical constructions derived therefrom.

New Researches in Reinforced Concrete. M. R. von Thullie. Beton u Eisen—Feb. 19, 08. 4 figs. 1200 w. $1.00. Discusses the effect of repeated loadings of beams.

Reinforced Concrete for Post Office Buildings. Con & Constr Eng—Mar, 08. 13 figs. 3200 w. 60c.

Reinforced Concrete in Reservoir, Aqueduct and Conduit Construction.—I. E. R. Matthews. Con & Constr Eng—Mar, 08. 6 figs. 2800 w. 60c.

Reinforced Concrete in the Building of a Cement Plant. Can Engr—Mar 6, 08. 5 figs. 2900 w. 20c. Describes methods used in constructing a plant at Longue Pointe, near Montreal.

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Reinforcement for Concrete. Emile G. Perrot. Ins Engg—Mar, 08. 2 figs. 2100 w. 40c.

Spiral Anchorage for Concrete Reinforcement. Daniel B. Luten. Eng News—Feb 27, 08. 3 figs. 1000 w. 20c. Cites instances where such reinforcement should be employed.

The "Advance" in the Concrete Age. Lt.-Col. J. Winn. Con & Constr Eng—Mar 08. 4700 w. 60c. Summarizes the principal features of the development of reinforced concrete in Great Britain during 1907.

The Investigations of C. Bach on Reinforced-Concrete Beams. K. Bernhard. Z V D I—Feb 8, 08. 18 figs. 3000 w. 60c. Describes apparatus used in Herr Bach's tests at the Royal Technical School, Stuttgart, and gives the conclusions arrived at from the results obtained.

The Manufacture of Concrete Reinforcing. Ir Tr Rev—Mar 12, 08. 11 figs. 1600 w. 20c. Describes the process of making Kahn trussed bars and expanded metals.

The Treatment of Concrete Surfaces. E. B. Green. Eng Rec—Feb 22, 08. 2400 w. 20c.

Retaining Wall of Concrete.

Cost of Mixing and Placing Concrete for a Retaining Wall. Rdmaster & F—Mar, 08. 1000 w. 20c.

Roofs.

The Failure of the Concrete Roof of the Lawrence, Mass., Filter. Eng News—Feb 27, 08. 1 fig. 1600 w. 20c.

The New Roof of Charing Cross (London) Station. Engg—Feb 7, 08. 44 figs. 2400 w. 40c.

Sewer.

An Intercepting Sewer in Salt Lake City, Utah. Eng Rec—Feb 22, 08. 1 fig. 1600 w. 20c.

Sheathing Piers.

Sheathing Piers on Lake Erie with Divers. Wilson T. Howe. Eng News—Feb 20, 08. 1700 w. 20c. Describes method used in a particular instance, with cost data.

Stone Cutting.

Stone Groining of a Semi-Circular Apse. John A. Marshall. Stone—Mar, 08. 12 figs. 1300 w. 40c. Shows the setting out and construction of an ordinary Gothic vault.

Track Elevation.

The Fortieth Street Track Elevation of the Chicago Junction Ry. R R Gaz—Feb 21, 08. 8 figs. 1500 w. 20c.

Tunnels

High-Temperature and Rock-Pressure Difficulties in Deep Tunnels. Chas. W. Comstock. Min Sc—Feb 13, 08. 1500 w. 20c. Abstract of article, "The Great Tunnels of the World," Proc Colo Scientific Society, Dec 7, 07.

The Opening of the First Hudson River Tunnel. Eng News. Feb 27, 08. 6 figs. 5300 w. 20c.

Waterproofing Cement Structures.

Waterproofing Cement Structures. James L. Davis. Cem Age—Feb, 08. 4500 w. 20c. Paper read before the National Association of Cement users, Buffalo, Jan 20-25, 08.

MATERIALS.

Cement.

A New Rotary Kiln Cement Plant. Engr (Lond)—Feb 28, 08. 10 figs. 3900 w. 40c. Describes a new plant at Greenhithe, England.

Calcination of Lime and Clay Mixtures to Make Portland Cement. F. J. Beal. Conc—Mar, 08. 4400 w. 20c.

How to calculate Portland Cement Clinker. Chem Engr—Feb, 08. 8000 w. 40c. Gives method for calculating the composition from the analysis of the raw material.

Portland Cement and Blast Furnace Slag Cement. H. Wedding. Stahl u Eisen—Feb 12, 08. 6000 w. 60c. Gives a comparison of their respective properties.

The New Mill of the California Portland Cement Company. Eng Rec—Mar 7, 08. 6 figs. 3800 w. 20c.

Steel, Corrosion of.

The Corrosion of Steel. Allerton S. Cushman. Jl Frankl Inst—Feb, 08. 3700 w. 80c. Paper read before the Franklin Institute, Nov 21, 07. Gives a brief explanation of the electrolytic theory of corrosion.

Wood Preservation.

Treating Wood that is Refractory to Treatment and Also Subject to Decay. David Allerton. Eng News—Feb 20, 08. 1600 w. 20c. Abstract of a paper read before the annual meeting of the United States Wood Preservers' Association, at Kansas City, Jan 21-23.

RIVERS, CANALS, HARBORS.

Breakwater, Aransas Pass, Tex.

History of the Reaction Breakwater at Aransas Pass, Tex. Lewis M. Haupt. Jl Frankl Inst—Feb, 08. 7 figs. 12,000 w. 80c. Paper read before the Franklin Institute, Jan 15, 08.

Canal Haulage.

Mechanical Haulage on Canals. Engr (Lond)—Feb 21, 08. 3400 w. 40c. Gives evidence presented to the Royal Commission on canals and waterways.

Notes on Electric Haulage of Canal Boats. Lewis B. Stillwell and H. St. Clair Putnam. Proc Am Inst E E—Mar, 08. 24 figs. 9000 w. 80c. A paper read before the American Institute of Electrical Engineers, Mar 13, 08.

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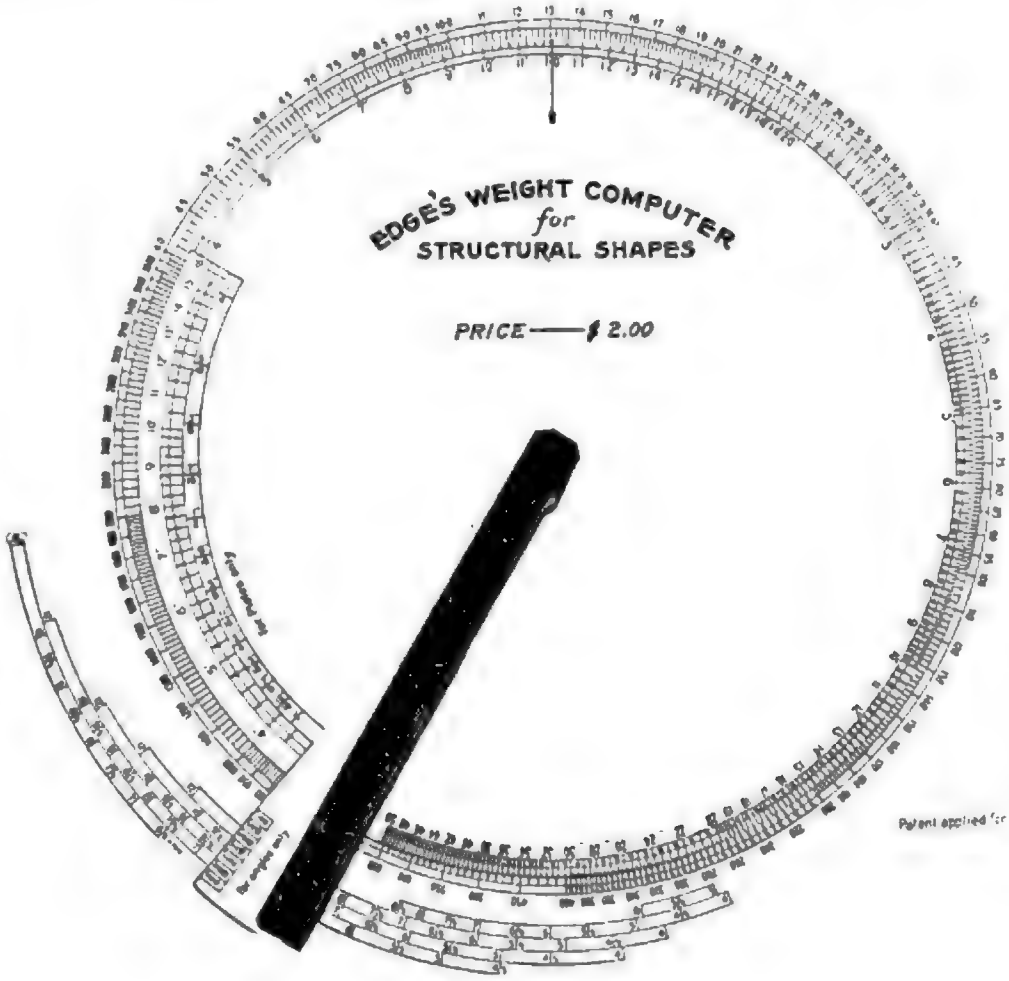

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Erosion of the Coast and Its Prevention. F. W. S. Stanton. Public Wks—Jan-Mar, 08. 1 fig. 2300 w. 60c.

Dredging.

Dredging Frozen Ground in Klondike. John Hutchins. Eng & Min Jl—Mar 7, 08. 1800 w. 20c.

Hydraulic Dredge for Reclaiming Land for Lincoln Park, Chicago. Eng News—Feb 27, 08. 2 figs. 1200 w. 20c.

The Fruhling System of Suction Dredging. John Reid. Eng News—Mar 5, 08. 3 figs. 3400 w. 20c. Describes a system in which the material is not only loosened, but is secured by a mechanical cutting of the surface, and in which the inrush of water at the suction pipe entrance is controlled.

Irrigation.

Lining the Ditches and Reservoirs to Prevent Seepage Losses. Prof. B. A. Etcheverry. Irrig Age—Mar, 08. 5 figs. 1200 w. 20c. Discusses the use of river boulders or cobbles set in cement mortar.

Jetty.

Reinforced Concrete Leading Jetty on the Manchester Ship Canal. Con & Constr Eng—Mar, 08. 6 figs. 800 w. 60c.

Sea Defenses.

Reinforced Concrete Sea Defenses. H. Huisman. Conc & Constr Eng—Mar, 08. 10 figs. 2400 w. 60c. II.—Dutch Examples.

Waterways.

Preliminary Report of the Inland Waterways Commission. (Condensed.) Eng News—Mar 5, 08. 7000 w. 20c.

The New York Barge Canal vs. the Deep Waterway. Eng News—Mar 5, 08. 3800 w. 20c. Communication from Col. T. W. Symons, and editorial comment on same.

SURVEYING, MENSURATION, ETC.

Alidade, Eccentricity of.

The Eccentricity of a Three-Microscope Alidade. Claude W. L. Filkins. Cornell Civ Engr—Feb, 08. 2 figs. 2000 w. 40c.

Astronomical Bearings by Sun Observations.

Astronomical Bearings by Sun Observations. D. D. James. Can Engr—Mar 6, 08. 2800 w. 20c. Describes a simple and accurate method.

Bench Level Operations.

Bench Level Operations on the Catskill Aqueduct Line. M. E. Zipzer. Eng News—Feb 20, 08. 3 figs. 2600 w. 20c.

Railway Curves.

A Railway Location Problem. Eng News—Mar 5, 08. 1 fig. 1000 w. 20c. Gives method used to connect a crossing of a straight and curved track by a curve, when both frog angles and the position of frog in straight track are fixed.

Curve Superelevation. M. L. Byers, R R Gaz—Mar 13, 08. 5 figs. 35,000 w. 30c. A mathematical study of the subject, with recommendations for use under present conditions of railroad practice.

The Middle Ordinate Problem. Rdmaster & Fore—Mar, 08. 1100 w. 20c. Gives a simple rule for figuring the middle ordinates for different degree curves and different lengths of rails.

Surveying.

Practical Points on Surveying. Charles L. Hubbard. Machy—Mar, 08. 16 figs. 4500 w. 40c. Describes the use of transit and level, methods of taking measurements, arrangement of notes; and the plotting of results, with special reference to locating buildings, establishing property boundaries, determining grades for drains, steam mains, etc.

ECONOMICS

Advertising.

Keeping Track of Advertising. J. Cecil Nuckols. Ir Age—Mar 5, 08. 4 figs. 1000 w. 20c. Gives forms used for this purpose by two Cincinnati manufacturing concerns.

Cost Accounting.

Graphic Analyses of Factory Costs. Edward T. Runge. Factory—Feb, 08. 5 figs. 1800 w. 40c. Tells how sales, manufacture and shipments can be analyzed, how purchase prices can be compared and how the relation between material, labor and expense can be immediately grasped by the executive.

Labor-Cost Distribution of the General Electric Shops, Lynn, Mass. Georgé F. Stratton. Eng Mag—Mar, 08. 5 figs. 3200 w. 40c. Describes system at a plant having eleven thousand employees drawing a total of $150,000 weekly.

Loose-Leaf Binders. J. H. Haertier. Min & Min—Mar, 08. 13 figs. 4200 w. 40c. Describes methods of recording data in regard to progress and cost of work and of filing general information.

System in Contracting Accounts. A. D. Williams. Con Eng—Feb, 08. 1600 w. 20c. Continued.

Engineer's Civic Duties.

The Engineer as a Man Among Men. Eng News—Feb 20, 08. 2700 w. 20c. Extracts from an address by Charles Whiting Baker, Editor of Engineering News, at the University of Vermont, Feb 10, 08.

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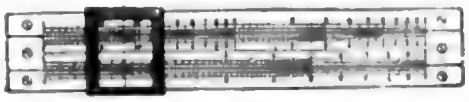

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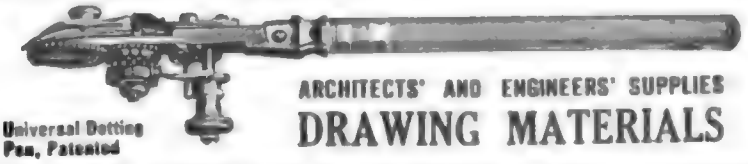

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Factory Management.

Cost Reduction for Manufacturing Plants. Maurice Gesundheit. Eng News—Mar 5, 08. 2 figs. 5700 w. 20c. A paper read before the Metal Manufacturers' Association of Philadelphia, Dec 19, 07.

Hurrying Factory Orders. Factory—Feb, 08. 2 figs. 600 w. 40c. Tells how factory production can be closely followed, how orders can be hurried and shipment promises fulfilled with less friction.

Making Machines More Efficient. F. M. Felker. Factory—Feb, 08. 4 figs. 2000 w. 40c. Discusses improvements in the design and arrangement of shafts and belting.

Routing Work Through the Shop. Ir Tr Rev—Feb 27, 08. 7 figs. 1100 w. 20c. Describes the system and forms used by the R. K. Le Blond Machine Tool Co., Cincinnati, Ohio.

Running a Factory by Schedule. Robert Daily. Factory—Feb, 08. 3 figs. 1200 w. 40c. IV.—Schedules for the Blacksmith Shop.

The Fundamental Principles of Works Organization and Management. P. J. Darlington. Eng Mag—Mar, 08. 5000 w. 40c. First of two articles devoted to the sorting and classifying of the special methods and systems used in a large number of shops.

Theory and Practice of Shop and Factory Management. Oscar E. Perrigo. Ir Tr Rev—Jan 2, 08. 1 fig. 3100 w. 20c. Fourth of a series of articles on cost keeping and shop management.

The Production System of the Westinghouse Electric and Mfg. Co. H. M. Wharton. Eng Mag—Mar, 08. 2 figs. 4200 w. 40c.

Patent Office, Criticisms of.

Does the Inventor Get a Square Deal at the Hands of the United States Government? H. Ward Leonard. Elec Wld—Mar 14, 08. A criticism of certain features of the Patent Office system.

On the State of the Patent Office. H. Addison Johnston. Machy—Mar, 08. 2700 w. 40c. Gives a detailed criticism of alleged faults in the present management.

Specifications.

Approximate Estimates. Alexander Potter. Eng Rec—Feb 22, 08. 2600 w. 20c. Discusses the limitations of the use of the phrase in engineering work.

Engineering Specifications. Walter S. Timmis. Ir Age—Mar 5, 08. 2900 w. 20c. Gives suggestions for their improvement and proposes a standard form.

ELECTRICAL ENGINEERING

ELECTROCHEMISTRY.

Diaphragm Cell.

Recent Developments in Electrolytic Cells. Henry S. Renaud. Eng & Min Jl—Feb 22, 08. 3 figs. 1100 w. 20c. Describes a new diaphragm cell for the decomposition of alkali chlorides.

ELECTROPHYSICS.

A. C. Commutator Motor Theory.

The Influence of the Short Circuit Current on the Phase Shifting in Alternating Current Commutator Motors. M. Osnos. Elek u Masch—Feb 23, 08. 58 figs. 2800 w. 60c.

The Theory of the Alternating Current Commutator Motor in Its Relation to that of Direct Current Motors. Elek u Masch—Feb 2, 08. 18 figs. 10,000 w. 60c.

Commutation, Laws of.

The Basic Laws of Commutation in Dynamos. R. Rüdenberg. Elek Zeit—Jan 23, 08. 4 figs. 6500 w. 40c.

Induction.

A New Factor for Induction; the "Loop" vs. the "Cutting Lines of Force" Laws. Carl Hering. El Wld—Mar 14, 08. 3 figs. 3700 w. 20c. A discussion favoring the latter based on a recent experiment by the author.

An Imperfection in the Usual Statement of the Fundamental Law of Electromagnetic Induction. Carl Hering. Proc Am Inst E E—Mar, 08. 4 figs. 4400 w. 80c. A paper presented at a meeting of the Philadelphia Section of the Am. Inst. of E. E., Feb 10, 08.

Losses in A. C. Motors.

The Curve Forms of Current in Three-Phase Motors and the Determination of Losses. K. Simons and K. Vollmer. Elek Zeit—Jan 30, 08. 11 figs. 4500 w. 40c.

The Separation of Losses in Asynchronous Motors. Indus Elec—Jan 25, 08. 15 figs. 3300 w. 60c.

Radio-Activity.

Recent Researches in Radio-Activity. Engg—Feb 7, 08. 5 figs. 2400 w. 40c. A A résume of a recent lecture at the Royal Institution by Prof. Ernest Rutherford.

GENERATORS, MOTORS, TRANSFORMERS.

A. C. Motors.

Single-Phase Motors vs. Multiphase Motors. R. J. Russell. West Elecn—Mar 14, 08. 3 figs. 2300 w. 20c. Paper (condensed) read before the Missouri Electric Light, Gas and Street Ry. Assn., at St. Louis, Oct 21, 07.

Converter.

The Cascade Converter. Elec Engr (Lond)—Mar 6, 08. 2 figs. 1300 w. 40c. Describes a machine consisting of an alternating current induction motor with "wound" rotor running with a large slip

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(usually 50%) and directly coupled mechanically to a direct-current dynamo—the rotor phases being connected directly, without the intervention of slip-rings, to a number of symmetrically spaced points on the direct-current armature winding.

D. C. Turbo-Generators.

The Development of Direct-Current Turbo-Dynamos. R. Pohl. Elek Zeit—Feb 6, 08. 10 figs. 4500 w. Feb 13, 9 figs. 500 w. Each 40c.

Polyphase Generators.

A New System of Winding for Polyphase Generators. F. Punga. Elek Zeit—Feb 6, 08. 3 figs. 4500 w. 40c.

Transformers.

Magnetic Alloy for Transformer Plates, etc. Mech Engr—Mar 6, 08. 600 w. 40c.

Small Transformers for Use with Metallic Filament Lamps. Elec Eng—Mar 5, 08. 7 figs. 4000 w. 40c.

LIGHTING.

Free Lamp Renewals.

Poor Light Complaints—A Central Station Problem. H. N. Muller. Elec Jl—Mar 08. 4 figs. 3000 w. 20c. Discusses the question of free lamp renewals.

Light Standards.

Primary Standard of Light. Charles P. Steinmetz. Proc Am Inst E E—Mar, 08. 2 figs. 1600 w. 80c. A paper to be presented at a future meeting of the American Institute of Electrical Engineers.

The Luminous Properties of Conducting Helium. P. G. Nutting. El Wld—Feb 22, 08. 2 figs. 2600 w. 20c. Abstract of a paper in the bulletin of the Bureau of Standards.

Tungsten Series Lamps.

Metal Filament Lamps. Alton D. Adams. Mun Jl & Engr—Mar 11, 08. 1900 w. 20c. Describes the use of series tungsten lamps for street lighting and gives a comparison with carbon filaments and mantle gas lamps.

Voltage Variation, Effect of.

The Effect of Varying the Voltage on Incandescent Lamps. F. Hirschauer. Elek Zeit—Jan 23, 08. 7 figs. 1800 w. 40c.

PLANTS AND CENTRAL STATIONS.

Motor Loads.

The Electric Motor Load from the Viewpoint of Central-Station Service. Charles K. Nichols. El Wld—Mar 7, 08. 4 figs. 3600 w. 20c.

Motors, Applications of.

Central-Stations and Electric-Motor Applications. El Wld—Mar 7, 08. 2300 w. 20c. Gives an extensive list of motor applications together with the power requirements of the various machines operated.

TELEGRAPHY AND TELEPHONY.

Telephone Line Construction.

Practical Suggestions on Telephone Construction Work. Bernard C. Groch. Telephony—Mar, 08. 1100 w. 20c. Proposed method that shows the lowest annual cost is almost invariably the proper method to employ for the construction work contemplated.

The Standard Specifications for Telephone Lines of the United States Reclamation Service. Eng News—Mar 12, 08. 3000 w. 20c.

Wireless Telegraphy.

A Direct System of Wireless Telegraphy. E. Bellini and A. Tosi. Elec Eng—Mar 5, 08. 10 figs. 3500 w. 40c.

TESTS AND MEASUREMENTS.

Electrical Measuring Instruments, Tests of.

Tests of Electrical Measuring Instruments. —I. F. Loppe. Indus Elec—Feb 25, 08. 1300 w. 60c. Comparison of various methods and values for testing wattmeters.

Meter Testing.

Testing Electric Meters at Their Place of Installation.—I. Joseph B. Baker. El Wld—Mar 7, 08. 3 figs. 2100 w. 20c.

TRANSMISSION, DISTRIBUTION, CONTROL.

Condensers on High Tension Circuits.

The Use of Condensers on High-Tension Circuits. Elec Engr—Mar 6, 08. 3 figs. 1200 w. 40c.

Conduit, Labor Cost of Laying.

Labor Cost of Laying Vitrified Clay Electric Conduit. De Witt C. Webb. Eng News —Mar 12, 08. 1100 w. 20c.

Current Rushes at Switching.

Current Rushes at Switching. J. S. Peck. El Jl—Mar, 08. 3 figs. 1600 w. 20c. Gives explanation of the phenomena taking place when transformers are switched on to a circuit.

Gas-Pipe Grounds, Resistance of.

Notes on Resistance of Gas-Pipe Grounds. J. L. R. Hayden. Proc Am Inst E E—Mar, 08. 3 figs. 1800 w. 80c. A paper read before the American Institution of Electrical Engineers, Niagara Falls, June 26, 07.

Grounding Neutral Point.

Advantages and Disadvantages in Grounding the Neutral Point in Tri-Phase Installations. Indus Elec—Feb 10, 08. 3200 w. 60c.

Insulators, Manufacture of.

High Voltage Insulator Manufacture. Walter T. Goddard. Can Elec News—Mar, 08. 8 figs. 3500 w. 40c. Paper read before the Electrical Section Canadian Society Civil Engineers.

Poles, Reinforced Concrete.

Method and Cost of Constructing and Erecting Reinforced Concrete Poles. Eng Contr—Mar 11, 08. 900 w. 20c.

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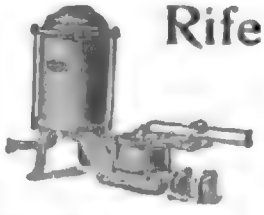

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Protective Devices.

Circuit-Interrupting Devices. F. W. Harris. El Jl—Mar, 08. 11 figs. 2000 w. 20c. V.—Carbon-Break Circuit Breakers.

Protective Relays. M. C. Rypinski. El Jl—Mar, 08. 5 figs. 1700 w. 20c. Alternating-Current Overload Relays—Single and Polyphase.

The Protection of Electric Circuits and Apparatus from Lightning and Similar Disturbances. R. P. Jackson. El Jl—Mar, 08. 13 figs. 2700 w. 20c.

Steel Towers.

Steel Towers for High Tension Transmission. Eng News—Mar 12, 08. 2 figs. 400 w. 20c. Describes towers 70 ft. high, intended to carry two circuits of three wires each transmitting a current of 100,000 volts.

Switchboard Operation.

Some Notes on Switchboard Operation in Alternating-current Stations. H. R. Mason. Power—Mar 10, 08. 1 fig. 1600 w. 20c.

MISCELLANEOUS.

Electric Driving.

Notes on Electric Driving. P. E. Severance. Am Mach—Mar 5, 08. 900 w. 20c.

Electric Fan Tests.

Comparative Tests of Different Types of Electric Fans. Arthur C. Scott. El Wld—Mar 7, 08. 7 figs. 2900 w. 20c.

Electric Power Possibilities.

Electric Power, Its Progress and Possibilities. A. H. Kimball. El Wld—Mar 7, 08. 5 figs. 3000 w. 20c.

INDUSTRIAL TECHNOLOGY

Acetylene Illumination.

The Illumination of the Homes by Acetylene. V. R. Lansingh. Acetylene Jl—Mar, 08. 13 figs. 1800 w. 20c. Paper read before the International Acetylene Association, at Washington.

Carbon Bisulphide.

Process and Apparatus for the Production of Carbon Bisulphide in the Electric Furnace. Edward R. Taylor. Jl Frankl Inst—Feb, 08. 13 figs. 5600 w. 80c. Paper read before the Franklin Institute, Dec 5, 1907.

Gas Engineering.

A Bulletin of Instruction on the Care and Operation of Recuperative Benches. (Continued.) Am Gas Lt Jl—Feb 17, 08. 2 figs. 22,000 w. 20c.

A Combined Coal and Water Gas Manufacturing Process. J. T. Wescott. Prog Age—Mar 2, 08. 3 figs. 700 w. 20c. Describes one unit of a water-gas apparatus, which consists of combining in one plant an inclined coal gas retort connected with an ordinary water-gas generator.

Operation of Recuperative Benches. W. A. Baehr. Prog Age—Mar 2, 08. 4 figs. 3500 w. 20c. Paper read before the American Gas Institute, Oct 16-18, 07.

The "Readiness-to-Serve" Cost of Gas Supply. W. H. Gardiner. Am Gas Lt Jl—Mar 9, 08. 1 fig. 5600 w. 20c.

Lime Burning.

The Schmatolla System of Gas-Fired Lime-Kilns. Engg—Feb 28, 08. 4 figs. 1500 w. 40c. Describes a successful type of kiln in which the stone is calcined by means of generator gas without coming in contact with the solid fuel.

Paper and Pulp Manufacture.

Developments in the Paper and Pulp Industry. Eng Rec—Feb 22, 08. 2500 w. 20c. Extracts from a paper recently read before the American Paper and Pulp Association by its chemist, Mr. Arthur D. Little.

Machinery and Power Required for the Production of Paper Pulp, Mechanical and Chemical, and Finished Paper. John W. Thurso. Eng News—Feb 20, 08. 2000 w. 20c. Gives data collected by the writer during the past 12 years, from various successful plants in the United States and Canada.

The Application of Electric Power to Pulp and Paper Mills—The Watab Pulp and Paper Company's Mills. Le Roy M. Harvey. El Wld—Feb 22, 08. 1 fig. 5800 w. 20c.

Purification of Gases.

Purification of Gases. Oskar Nagel. Electrochem & Met Ind—Mar, 08. 10 figs. 5000 w. 40c. Describes methods used in the separation of gases from solids, from liquids, and from gases.

Silicon Monoxide.

Manufacture and Uses of Monox. E. Lemaire. Génie Civil—Feb 15, 08. 1 fig. 2000 w. 60c.

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MARINE ENGINEERING

Estimates.

Marine Engineering Estimates. C. R. Bruce. Mech Wld—Feb 21, 08. 2000 w. 20c. Continued.

Heating and Ventilation of Ships.

The Heating and Ventilating of Ships. Sydney F. Walker. Int Mar Eng—Mar, 08. 7 figs. 3600 w. 40c. Describes the forms of heating apparatus using hot water.

The Ventilation of Battleships. G. Guellmann. Gesund-Ing—Feb 15, 08. 7000 w. 80c. Paper read before the International Congress for Hygiene and Demography.

Marine Boilers.

Boilers in the French Navy. Engg—Feb 21, 08. 1800 w. 40c. Discussion in the French Senate with reference to the type of boilers proposed for the six battleships of the Danton class, to be engined with Parsons turbines.

The Use of Lime in the Modern Marine HP. Boiler. Mar Engr & Nav Arch—Mar 1, 08. 2 figs. 4000 w. 40c.

Motor Boats.

High-Speed Motor Boats for Pleasure Use. Henry S. Sutphen. Int Mar Engg—Mar, 08. 12 figs. 1800 w. 40c. Read before the Society of Naval Architects and Marine Engineers, New York, Nov 21, 07.

Some Observations on Motor-Propelled Vessels and Notes on the Bermuda Race. William B. Stearns. Int Mar Eng—Mar, 08. 2 figs. 4400 w. 40c. Read before the Society of Naval Architects and Marine Engineers, New York, Nov 21, 07.

The Racing Motor-Launch "Siddeley-Wolseley." Engg—Feb 21, 08. 8 figs. 1800 w. 40c.

Power Measurement of Marine Turbines.

Torsion-Meters. J. Hamilton Gibson. Engg—Feb 7, 08. 32 figs. 7800 w. 40c. Paper read before the North-East Coast Institution of Engineers and Shipbuilders, Jan 24, 08. Discusses the application of torsion-meters to the measurement of the horse-power of marine steam turbines.

Rams as Naval Weapons.

The Ram in Its Modern Aspect. G. Paschen. Schiffbau—Feb 12, 08. 6 figs. 2000 w. 60c. Discusses the ram as a weapon in naval warfare.

Stability, Test for.

An Inclining Experiment. Harold F. Norton. Sibley Jl—Feb, 08. 3 figs. 2400 w. 40c. Describes method whereby vessels are tested for stability.

Steam Collier.

The Steam Collier "Everett" for the New England Coal and Coke Company, Boston, U. S. A. Engg—Feb 7, 08. 6 figs. 1000 w. 40c.

Submarines.

Italy's Progress in Submarine Navigation. Engr (Lond)—Feb 14, 08. 1 fig. 3000 w. 40c.

Paraffin Engine for Submarines. Engr (Lond)—Feb 7, 08. 3 figs. 1500 w. 40c. Describes a new Thorneycroft paraffin motor, designed for the Italian Navy.

Tank Steamers, Safety Devices for.

Safety Devices on Tank Steamers. M. M. Dikos. Compt Rend Ing Civ de France—Nov, 1907. 4 figs. 40,000 w. $1.20. Discusses methods for protecting steamers transporting inflammable oils from possibility of fire.

MUNICIPAL ENGINEERING

Air Compressors.

Setting the Valve-gear of Air Compressors. Claude Aikens. Power—Feb 18, 08. 9 figs. 2300 w. 20c. Discusses the importance of piston clearance; how to determine relative positions of crank-pin and eccentric; and the setting of blowing-engine valves.

The Efficiency of Dry Air Compressors. W. Heilemann. Z V D I—Feb 8, 08. 23 figs. 4500 w. 60c. Gives results of tests by Dr. Mollier on a compressor plant in the laboratory of the Dresden Technical High School.

Compressed Air Calculations.

Compressed Air Calculations. E. A. Rix. Jl of Elec Pr & Gas—Feb 29, 08. 4000 w. 20c. Paper read before the Mining Association of the University of California, Feb 19, 08. Gives formulas and data, with examples of their application.

Flow of Air and Gases.

The Flow of Compressed Air in Pipes, with Special Reference to Mining on the Rand. E. J. Laschinger. Min Jl—Feb 22, 08. 12,000 w. Mar 7. 4000 w. Each 40c. Paper read before the Transvaal Institute of Mechanical Engineers.

The Measurement of Gas Flow Through Thin Orifices. A. O. Mueller. Z V D I—Feb 22, 08. 8 figs. 5500 w. 60c. Gives contraction coefficients for various conditions, by the use of which the quantity of gas flowing through thin orifices may be measured.

Liquid Air Manufacture.

Place's Air-Liquefying Expansion Engine. J. F. Place. Com Air—Mar, 08. 7 figs. 3400 w. 20c. Gives a number of indicator cards taken at low temperature from the air-expanding engine of an air-liquefying plant producing 7½ lbs. of liquid air per HP.-hour energy expended.

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FOUNDING.

Brass and Copper Founding.

Silicon-Copper in the Brass Foundry. C. Vickers. Fdry—Mar, 08. 5 figs. 2200 w. 20c. Discusses the properties and use of this valuable alloy, and gives mixtures to be used.

Spongy (Copper and Brass) Castings Their Causes and Prevention. Ernest A. Lewis. Met Indus—Feb, 08. 1000 w. 20c.

Cores.

The Advantages of Core Molding. J. F. Buchanan. Fdry—Mar, 08. 14 figs. 2400 w. 20c.

Use of Metal Cores in the Foundry. George Buchanan. Fdry—Mar, 08. 9 figs. 700 w. 20c.

Coke Consumption in Cupolas.

The Coke Consumption in Cupola Furnaces.—II.—G. Buzek. Stahl u Eisen. Feb 12, 08. 3500 w. 60c.

Cupola Charging Machines.

Charging Machines for Cupolas. G. R. Brandon. Ir Tr Rev—Mar 12, 08. 7 figs. 1300 w. 20c. A paper read before the Pittsburg Foundrymen's Association, Mar 2, 08.

Foundry Lighting and Ventilation.

Foundry Lighting and Ventilating. R. M. Graham. Factory—Feb 20, 08. 3 figs. 700 w. 40c. Shows how an abundance of light and fresh air can be provided, and what practical results have followed a unique building construction.

Handling Materials in Foundries.

Transportation in the Iron Foundry. Oscar E. Perrigo. Castings—Feb, 08. 3 figs. 2800 w. 20c. Discusses the problem of handling materials.

Iron From Cupola Slag.

The Recovery of Iron from Cupola Slag. Robert Grimshaw. Ir Tr Rev—Jan 2, 08. 700 w. 20c.

Malleable Castings.

Making Malleable Castings Without Annealing. Dr. Richard Moldenke. Fdry—Mar, 08. 1000 w. 20c.

Production of Malleable Castings. Dr. Richard Moldenke. Ir Tr Rev—Feb 27, 08. 3300 w. 20c. II.—Characteristics of malleables and their physical and chemical properties—methods of testing.

Scientific Founding.

The Application of Science to Foundry Work. Robert Buchanan. Mech Engr—Feb 21, 08. 3600 w. Feb 28. 2800 w. Each 40c. Paper read before the Royal Society of Arts, Feb 12, 08.

Stand Pipe.

Molding a Four-Way Stand Pipe. George Buchanan. Am Mach—Feb 27, 08. 5 figs. 900 w. 20c.

Steel Castings.

Development of the Steel Casting Industry. W. M. Carr. Ir Tr Rev—Jan 2, 08. 1600 w. 20c.

Steel Castings by the McHaffie Process. Ir Tr Rev—Jan 2, 08. 6 figs. 1100 w. 20c.

Sweep for Cylindrical Work.

Cylindrical Section Sweeping Device. Jabez Nall. Fdry—Mar, 08 5 figs. 1600 w. 20c. Describes equipment for sweep molding section of large cylindrical castings.

Waste in Foundries.

Foundry Waste. Dr. Richard Moldenke. Ir Age—Mar 12, 08. 2100 w. 20c. A paper read at the convention of the Chicago Foundry Foremen's Association, Mar 5, 08.

Sixteen Ways to Lose a Casting. Wilber R. Tilden. Ir Age—Feb 20, 08. 16 figs. 3200 w. 20c. Illustrates 16 castings from the same pattern, showing some of the more common defects in molding and pouring.

HEATING AND VENTILATION.

Department Store, Mechanical Equipment of.

Heating and Ventilating a Modern Department Store. John G. Eadie. Htg & Vent Mag—Feb, 08. 8 figs. 4500 w. 20c. Describes the mechanical equipment of B. Altman & Co.'s new building, New York City.

Central Heating Plants, Cost of.

Calculation of Costs for Central Heating Plants. F. Janeck. Gesund. Ing—Feb 1, 08. 12,000 w. 80c.

Hot Water Supply.

Hot Water for Domestic Use.—I. Jno. K. Allen. Dom Engr—Mar 7, 08. 2 figs. 1200 w. 20c.

Steam Heating.

Modern Steam Heating Illustrated.—I. B. F. Raber. Dom Engr—Mar 7, 08. 1 fig. 1500 w. 20c. First of a series of articles discussing the various systems of steam heating, their design and erection.

HOISTING AND HANDLING MACHINERY.

Coal Dock Hoist.

A New Coal Hoist at Leith. Engr (Lond)—Mar 6, 08. 4 figs. 5000 w. 40c. Describes a new 30-ton movable hydraulic coal hoist at the Imperial Dock, Leith, designed for dealing with end tip wagons of a gross weight of 30 tons, which can be lifted to a height of 61 ft. above the quay level and there be tipped.

Elevators.

The Hydraulic Elevator. William Baxter, Jr. Power—Feb 18, 08. 6 figs. 1300 w. Mar 10, 08, 2 figs. 1700 w. Each 20c. XIX.—Describes the Whittier pulling machine; best method of lubrication; the use of strainers. XX.—Discusses the use of strainers with the Crane machine, and the care and management of the Morse and William pulling machine.

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Equipments for Industrial Plants.

Economical Material-Handling Equipments for Industrial Plants. Werner Boecklin. Eng Mag—Mar, 08. 47 figs. 7500 w. 40c. Profusely illustrated descriptive article on industrial railways, cableways, cranes, hoists and various forms of conveyors.

Floating Crane.

140-Ton Floating Crane. W. Kaemmerer. Z V D I—Feb 22, 08. 11 figs. 1800 w. 60c.

Fuel and Ash Handling.

Fuel and Ash Handling Equipment. O. M. Becker and William J. Lees. Factory—Feb, 08. 11 figs. 2100 w. 40c. Gives practical suggestions as to the various types of equipment available, the choice of apparatus to meet given conditions, and the results which follow

Handling Bank Vault Plates.

Handling Heavy Armor-Plates for a Bank Vault. Eng News—Mar 5, 08. 1100 w. 20c. Describes methods used on a difficult job involved in the construction of vault for the Carnegie Trust Co. in New York City.

Hoisting Machinery for Construction Work.

Moisting Machinery for the Handling of Materials. T. Kennard Thomson. Eng Mag—Mar, 08, 19 figs. 4500 w. 40c. Describes the various classes of hoisting machinery used in construction work.

Modern Hoisting and Conveying Systems.

Modern Systems of Hoisting and Conveying. Walter G. Stephan. Ir Tr Rev—Jan 2, 08. 33 figs. 8000 w. 20c. Discusses the many systems available and the special field of each.

Overhead Railways.

New System of Overhead Railways. M. Buhle. Stahl u Eisen—Feb 26, 08. 5 figs. 2000 w. 60c. Describes two electrically operated systems in which the cars are hung from trolleys running on overhead rolled steel rails or I-beams

Some German Overhead Tramways. Alfred Gradenwitz. Eng & Min Jl—Feb 29, 08. 19 figs. 2600 w. 20c. Describes the transportation of material by overhead electric tramways and improvements in practice in construction of tramways.

HYDRAULIC POWER PLANTS.

High Head Francis Turbine.

High Head Francis Turbine at Centerville, Cal., Power Plant. Jl El Pr & Gas—Feb 29, 08. 6 figs. 2400 w. 20c. Describes a 9,700-HP. unit under an effective head of 565 ft.

Hydroelectric Plants.

Caffaro-Brescia Electric Power Transmission Plant. Dr. Alfred Gradenwitz. West Elecn—Mar 14, 08. 2 figs. 1300 w. 20c. Describes a new high tension plant and transmission in northern Italy.

The Brusio Hydroelectric Plant and Power Transmission in Lombardy.—II. Schw Bau—Feb 15, 08, 11 figs. 2500 w. $1.00. Gives details of a new development in Northern Italy.

The Colliersville (N. Y.) Hydroelectric Plant. Eng Rec—Mar 7, 08. 7 figs. 1800 w. 20c. Describes a power plant just completed to furnish power for the 65-mile line of the Oneonta & Mohawk Valley Railroad and for power and lighting purposes in adjacent towns and villages.

The Hydroelectric Plant of the Rockingham, N. C. Power Company. Julian S. Miller. Elec Rev—Mar 14, 08. 6 figs. 2700 w. 20c. Describes a project on the Yakin River, to supply 28,800 hydroelectrical HP.

Pumping Engine Tests.

Testing of High-Duty Pumping Engines by Modern Practice. Ind Wld—Feb 24, 08. 7700 w. 20c. Gives description of method for conducting tests and results of investigations on three triple-expansion pumping engines in St. Louis.

INTERNAL COMBUSTION ENGINES.

Alcohol Engines.

Tests of Gasoline and Kerosene Engines with Alcohol Fuel. S. M. Woodward. Eng News—Mar 12, 08. 7 figs. 7500 w. 20c. Gives résumé of the final report upon the investigations carried out by the U. S. Department of Agriculture upon the availability of alcohol as engine fuel.

Engine Proportions.

Gas and Steam-Engine Proportions. W. H. Booth. Power—Mar 3, 08. 1100 w. 20c.

Exhaust.

The Exhaust of the Internal-Combustion Engine. H. Addison Johnson. Power—Feb 25, 08. 1800 w. 20c. Shows how the condition of the mechanism of an engine may be ascertained by an examination of the exhaust.

Explosive Combustion.

Experiments on the Rapidity of Combustion of Explosive Gas Mixtures. A. Naegel. Z V D I—Feb 15, 08. 14 figs. 9000 w. 60c.

Explosive Combustion of Hydrocarbons. Engg—Mar 6, 08. 2600 w. 40c. Résumé of lecture before the Royal Institute, Feb 28, 08. Discusses the subject chiefly from the chemical standpoint.

Installations at Buenos Ayres.

Gas Engine Installations at Buenos Ayres. Eng Rec—Mar 7, 08. 3 figs. 2700 w. 20c.

Lubrication of Large Engines.

Lubrication of the Larger Sizes of Gas Engines. R. R. Keith. Power—Feb 18, 08. 1 fig. 1600 w. 20c.

Oil Engines.

Technical Aspects of Oil as Fuel.—VII.-IX. F. E. Junge. Power—Feb 18, 08. 1 fig. 700 w. Feb 25. 4 figs. 1600 w. Mar 3. 3 figs. 1500 w. Each, 20c. Dis-

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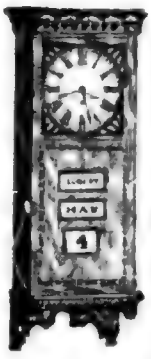

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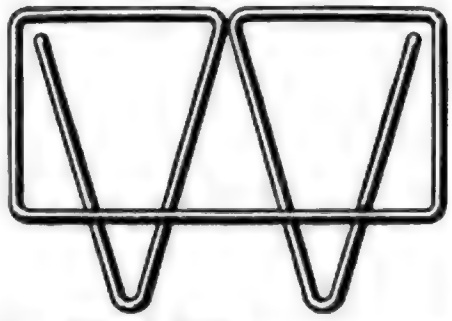

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cusses are construction and efficiency of oil engines (Daimler, Diesel, Haselwander) using benzol and other low-priced coal-tar oils, and the defects of combustion in Diesel engines.

Tar Destruction in Producer Gas.

The Destruction of Tar in Gas-Producers. H. P. Bell. Engg—Feb 7, 08. 9 figs. 3700 w. 40c.

MACHINE PARTS.

Flywheel of Structural Steel.

A New Structural Steel Flywheel. Engr—Feb 15, 08. 2 figs. 700 w. 20c. Describes a wheel in which the spokes are made of structural steel and the rim of a trough of such steel filled with steel wire ropes.

Helical Gears.

Machine-Cut Double Helical Wheels. Engg—Feb 21, 08. 8 figs. 2000 w. 40c. Describes the Wuest system of generating both sets of spiral teeth in a single-wheel blank by using two hobs of opposite hand to cut the teeth simultaneously.

Roller Bearings.

Roller Bearings; Design, Construction and Use. A. E. D. Can Machy—Mar, 08. 6 figs. 1100 w. 20c. Gives particular attention to the straight roller bearing, with illustrations of bearings used in agricultural machinery and trucks.

Self-Alining Taper Roller Bearings. H. W. Alden. Automobile—Feb 27, 08. 3 figs. 1400 w. 20c. Presents some facts concerning the design and action of certain forms of roller bearings and illustrates their practical application to various automobile conditions.

Speed Changing Device.

Two Speeds from Constant Drive. Albert Walton. Am Mach—Feb 28, 08. 2 figs. 1100 w. 20c. Describes a device of use in textile machinery.

MECHANICS.

Chain Rings, Strength of.

Stresses in Solid Beam Sections and the Strength of Chain Rings.—II. Robert H. Smith. Engr (Lond)—Feb 7, 08. 1 fig. 2000 w. 40c.

Elastic Limit, etc.

The Limit of Proportionality and the Elastic Limit. Henry Hess. Am Mach—Mar 12, 08. 2 figs. 1200 w. 20c. Proposes more precise definitions of elastic limit, yield point deformation, etc.

Governor Springs, Deflection of.

The Deflection of Rotating Spiral Governor Springs. J. Zvonicek. Z V D I—Feb 22, 08. 3 figs. 1800 w. 60c. Gives formulas and illustrative calculations.

Stresses.

Maximum Stresses.—I. John S. Myers. Machy—Mar, 08. 3 figs. 5500 w. 40c. Presents a few common cases of variable and of combined stresses, showing the manner of obtaining the maximum stresses for which machine parts should be designed, these various cases leading up to the presentation of tables and diagrams whereby the labor of computing the stresses may be very much shortened.

METAL WORKING.

Auger Making.

Auger Making in an Old American Shop. Am Mach—Feb 20, 08. 9 figs. 1600 w. 20c.

Boring.

A Combination Boring Bar for Boring, Reaming and Facing. John Edgar. Can Machy—Mar, 08. 10 figs. 2100 w. 20c.

Single-Bar Boring Machine for Multiple Cylinders. E. J. McKernan. Am Engr & R R Jl—Mar, 08. 3 figs. 1500 w. 40c.

Cams.

Two Methods of Making Master Cams. W. V. Lowe. Am Mach—Feb 27, 08. 2 figs. 2400 w. 20c.

Case-Hardening.

Case-Hardening Steel with Gas. E. F. Lake. Am Mach—Feb 20, 08. 9 figs. 2600 w. 20c. Describes a special gas carbonizing furnace and some pieces case-hardened in it which would be very difficult to carbonize by the old method of packing in bone, charcoal, charred leather, etc.

Chain Machinery.

Recent Advances in Machinery for Making Welded Chain. Stahl u Eisen—Feb 19, 08. 6 figs. 1800 w. 60c.

Die.

A Sectional Die. L. E. Salmon. Am Mach—Mar 12, 08. 1 fig. 500 w. 20c. Gives sketch showing approved method of constructing a large die of irregular shape.

File Testing.

Recent Improvements in File Testing. Eng News—Feb 20, 08. 1900 w. 20c. Describes an automatic testing and indicating machine recently brought out in England.

Gear Cutting.

Gear-Cutting Machinery.—III. Ralph E. Flanders. Machy—Mar, 08. 21 figs. 6500 w. 40c.

Hobbing Bevel Gears with a Taper Hob. E. Gregory. Am Mach—Mar 5, 08. 4 figs. 900 w. 20c. Describes a new principle in gear hobbing employing a taper hob and the special machine designed for the work.

Grinding.

Notes on the Use of Grinding Machines. J. E. Livermore. Engg—Mar 6, 08. 4 figs. 8000 w. 40c.

Machine Tools.

Some English Machine Tools and Methods. J. W. Carrell. Am Mach—Mar 12, 08. 12 figs 2100 w. 20c. Describes some interesting types differing from American designs, useful small tools, limits of accuracy and noteworthy methods.

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Some Features of English Milling Machines and Practice. H. A. Carter. Can Machy—Mar, 08. 3 figs. 1800 w. 20c. Gives useful data and hints to makers and operators, particularly on the care of milling cutters.

Some Interesting Antique Machine Tools. E. A. Dixie. Am Mach—Feb 27, 08. 2 figs. 1400 w. 20c. Illustrates modern features found in an engine lathe 74 years old, and points out the difficulty of departing from existing standards.

Some Planing Machine History. T. E. Shaw. Mech Engr—Mar 6, 08. 9 figs. 5200 w. 40c. Paper read before the Coventry Engineering Society.

Machining Cylinders and Motor Frames.

Machining a Street-Car Motor Frame. P. Fenaux. Am Mach—Mar 12, 08. 5 figs. 2600 w. 20c.

Machining Cylinders in a Glasgow Shop. Henry Munro. Am Mach—Feb 20, 08. 10 figs. 3400 w. 20c. Describes the methods and tools used in making engines for heavy motor vehicles.

Screw Machines.

Cam Adjustment on Automatic Screw Machines. Am Mach—Feb 20, 08. 4 figs. 1200 w. 20c.

Steel Disc Saw, Toothless.

The Action of Toothless Circular Saws. F. W. Harbord. Engr (Lond)—Feb 21, 08. 6 figs. 1000 w. 40c. Gives an explanation, based on microscopic examination of the phenomenon of a soft steel disc revolving at a high speed cutting hard steel.

Dies and Taps for Automatic Screw Machines. C. L. Goodrich and F. A. Stanley. Am Mach—Mar 12, 08. 24 figs. 3200 w. 20c. Describes method of making spring and button dies and various kinds of taps with suitable clearance and cutting properties for screw-machine operations.

Forming Tools for Automatic Screw Machines. C. L. Goodrich and F. A. Stanley. Am Mach—Feb 27, 08. 36 figs. 4000 w. 20c. Describes the making of circular and dovetail forming tools with proper clearances and dimensions and their application to screw-machine work.

Steel, Heat Treatment of.

Alterations of Steel in Heat Treating. J. E. Storey. Am Mach—Feb 20, 08. 6 figs. 2400 w. 20c. Gives tabulated and charted results of the expansion and contraction of steel with different degrees of temperature in hardening.

The Treatment of High-Speed Steel. Ethan Viall. Am Mach—Feb 27, 08. 2300 w. 20c. Gives the directions sent out by makers of a number of well-known brands of steel, with comments based on the author's experience.

The Work Shop Treatment of Steel. Walter Rosenhain. Ir Tr Rev—Feb 20, 08. 2000 w. 20c. From the Engineering Supplement of the "London Times."

Taps.

Taper Taps.—I. Erik Oberg. Machy—Mar, 08. 5 figs. 3500 w. 40c.

Welding.

The Alumino-Thermic Welding Process. A. I. Graham. Mech Engr—Feb 7, 08. 2 figs. 2400 w. 40c. Lecture before the South Wales Institute of Engineers.

REFRIGERATION.

Boiler Foaming and Priming.

Foaming and Priming in Boilers of Ice Plants. John C. Sparks. Ice & Ref—mar, 08. 3000 w. 40c.

Brine Temperature, Rise in.

Cause of Rise in Temperature in Ice Tank. R. L. Shipman. Ice & Ref—Mar, 08. Discusses the rise in temperature of brine in freezing tank with the increase of suction pressure by increasing the expansion.

Plaza Hotel Plant.

Refrigerating Plant of the Plaza Hotel. J. C. La Vin. Cold Stor & Ice Tr Jl—Feb, 08. 11 figs. 2000 w. 40c.

Alining Shafting.

Alining Shafting by a Steel Wire. A. H. Nourse. Am Mach—Mar 5, 08. 2 figs. 1000 w. 20c. Describes method and gives a table showing the sag of such wire for various lengths between supports.

Drafting Room System.

A Simple and Complete Drafting-Room System. Wm. F. Zimmerman. Am Mach—Mar 12, 08. 15 figs. 3000 w. 20c. Gives details of a carefully planned connected and modified system successfully employed by a large machine-tool building firm.

Engineering Works, Austria.

The Skoda Works, Pilsen. Engg—Mar 6, 08. 20 figs. 6000 w. 40c. Describes most important company in Austria, in that it combines the manufacture of steel with the construction of ordnance and artillery and with engineering in all its branches.

Factory Moving.

Moving a Factory by a Plan. H. C. Haggerty. Factory—Feb, 08. 8 figs. 1900 w. 40c. Tells how a plant was moved eight miles without seriously interrupting production, and without loss of material or breakage.

Modern Boiler Shop.

The Boiler Shop of the Harlan & Hollingsworth Corporation. Charles S. Linch. Boiler Mkr—Mar, 08. 5 figs. 2000 w. 20c. Describes one of the most modern boiler shops in the United States—at Wilmington, Del.

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Power Equipment for the Small Factory. Percival R. Moses. Eng Mag—Mar, 08. 29 figs. 6500 w. 40c. Presents the problem confronting the designer of factory equipment, and shows the more important factors which should receive consideration in determining the character of the plant so that it may do its work in the most economic way.

Shop Improvement.

The Regeneration of the Old Shop. Am Mach—Mar 5, 08. 7 figs. 1800 w. 20c. Describes the way in which a new management abandoned old methods and specialized in the manufacture of woodworking machinery.

STEAM POWER PLANTS.

Air Pumps and Condensers.

Air Pumps and Condensers. R. M. Ferguson. Mech Engr—Feb 28, 08. 4 figs. 4000 w. 40c. Paper read before the Manchester Association of Engineers, Feb 22, 1908.

The Corrosion of Condenser Tubes. E. C. Sickles. Power—Mar 10, 08. 16 figs. 3800 w. 20c. Discusses the influence of this factor on the choice of condenser equipment for power plants using salt circulating water.

Boilers.

Advantages of Corrugated Flues. Vernon Smith. Pract Engr (Lond)—Feb 21, 08. 6 figs. 1700 w. 40c.

Blow-Off Valves for Steam Boilers. R. T. Strohm. El Wld—Mar 7, 08. 9 figs. 3400 w. 20c.

Estimating the Cost of Repair Work. James Crombie. Boiler Mkr—Mar, 08. 3 figs. 2700 w. 20c.

Failures and Specifications of Firebox Steel. M. H. Wickhorst. Boiler Mkr—Mar, 08. 3000 w. 20c. From a paper presented before the American Society for Testing Materials.

Layout of an Up-take. Henry Mellon. Boiler Mkr—Mar, 08. 4 figs. 900 w. 20c.

Massachusetts Boiler Rules. Power—Mar 3, 08. 2900 w. 20c.

Proportions of Steam Boilers. John Cook. Boiler Mkr—Mar, 08. 1 fig. 3000 w. 20c.

Economizers.

Economizers. W. W. Melville. Public Wks—Jan-Mar, 08. 4400 w. 60c.

Feed-Water.

Simple Methods of Testing Feed-Water and Lubricants. James E. Noble. Pract Engr (Lond)—Feb 7, 08. 1 fig. 1500 w. 40c.

Test of a Live-Steam Feed-Water Heater. John Goodman and D. R. MacLachlan. Engg—Feb 28, 08. 2 figs. 3500 w. 40c. Gives data showing there is no saving effected in heating with live-steam.

Water for Economical Steam Generation. J. C. Wm. Greth. Eng Mag—Mar, 08. 8 figs. 8000 w. 40c. Gives statistics for a large number of cases showing the saving due to the installation of proper water-softening apparatus.

Flue-Gas Analysis.

Flue-Gas Analysis and Boiler Efficiency. William D. Ennis. Power—Mar 3, 08. 3400 w. 20c. Describes the application of flue-gas analysis to the determination of the air supply, furnace losses and estimation of efficiency.

Flywheel Accidents.

Recent Flywheel Accidents. Power—Mar 3, 08. 1000 w. 20c.

Fuel.

Crude Oil as Fuel. Wm. Chaddick. Engr—Mar 2, 08. 9 figs. 1200 w. 20c. Gives instructions for oil testing, details regarding its combustion, and points on installing system.

Method of Testing Coal. S. S. Voorhees. Min & Min—Mar, 08. 4000 w. 40c. A paper read before the Society for the Testing of Materials. Gives results of analyses and tests of coal purchased for United States Governments Buildings in different cities.

Knocks in Engines.

Causes of Knocks in Steam Engines.—II. & III. C. J. Larson. Power—Feb 18, 08. 3 figs. 1700 w. Feb 25. 3 figs. 1400 w. Each, 20c.

Low-Pressure Steam.

Use of Low-Pressure Steam from Compound Engines. Eng Rec—Feb 22, 08. 3 figs. 1300 w. 20c. Describes apparatus for maintaining constant pressure in the receiver of a compound engine from which steam is drawn for heating, drying, dyeing, etc.

Piston Speed, Limits of.

Limits of Piston Speed. Frederick Strickland. Engg—Feb 7, 08. 1500 w. 40c.

Recording Gage Charts.

Finding the Average Pressure from Round-Pattern Pressure-Recording Gage Charts. A. V. Youens. Power—Mar 3, 08. 2 figs. 800 w. 20c.

Smokestack and Water Tank.

The Construction of a Combined Smokestack and Water Tank. H. Stoffels. Eng News—Mar 12, 08. 3 figs. 1300 w. 20c. Describes a combined elevated water tank and a brick smokestack which carries the tank, but projects through and above it, with analyses of the stresses in chimney and tank.

Steam Plant Testing.

Testing of Steam Electric Power Plants.—I. Frank Koester. El Rev—Feb 22, 08. 5 figs. 1800 w. Feb 29. 2400 w. Each, 20c. Two articles covering methods of conducting tests of complete steam-electric power plants.

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Proper Method of Testing a Steam Turbine. Thomas Franklin. Power—Mar 10, 08. 10 figs. 4200 w. 20c. Discusses the prevention of dummy leakage and the importance of the oiling system and water service, etc.

Some interesting Features of Steam Turbine and Steam Engineering Construction. Mech Engr—Feb 7, 08. 3 figs. 2600 w. Feb 21. 5 figs. 2100 w. Each, 40c.

Steam Turbine Construction.—IV. & V. T. Franklin. Mech Wld—Feb 7, 08. 16 figs. 1300 w. Feb 21. 2 figs. 700 w. Each, 20c.

Steam Turbines. W. L. R. Emmett. Engr—Mar 2, 08. 1600 w. 20c. Lecture delivered before the Schenectady Section A. I. E. E. Sets forth the advantages in efficiency and capacity, and reasons for use of stages.

The Belluzzo Two-Speed Steam Turbine. Engg—Feb 28, 08. 3 figs. 800 w. 40c. Describes a turbine designed to give practically the same efficiency at half speed as at full speed.

The Brush-Parsons Turbine Machinery. Engg—Feb 14, 08. 39 figs. 5500 w. 40c. Gives details of construction of the Parsons type of steam turbine manufactured by this company for use in turbo-generators.

The Curtis Steam Turbine in Practice.—II. & III. Fred. L. Johnson. Power—Feb 25, 08. 7 figs. 600 w. Mar 10. 9 figs. 1100 w. Each, 20c. II.—Gives details of construction, with simple, practical directions for operation and adjustment. III.—Discusses the correct determination of the clearance between buckets and intermediates; the safety-stop, valve-gear, governor and stage valves.

The Elektra Steam Turbine. H. Meuth. Z V D I—Feb 8, 08. 14 figs. 2200 w. 60c. II.—Describes the application of this motor and also the Kolb rotating condenser used in connection therewith.

The Hulhouse Central Station Steam Turbine Plant. Frank C. Perkins. Can Engr—Mar 6, 08. 4 figs. 1000 w. 20c.

The Question of Steam Turbine Safety Governors.—I. Prac Engr—Mar, 08. 2000 w. 40c.

The Steam Path of the Turbine. Charles P. Steinmetz. Proc Am Soc M E—Mar, 08. 4 figs. 9000 w. 80c. Presented at the March meeting of the Am. Soc. M. E. Mathematical analysis of the action of steam in a turbine.

Turbine Economics. J. R. Bibbins. El Wld—Feb 29, 08. 3 figs. 5000 w. 20c. A criticism of a recent article by W. L. R. Emmett comparing the Curtis and Parsons turbines in regard to efficiency.

Superheated Steam, Specific Heat of.

The Specific Heat of Superheated Steam. Prof. Sidney A. Reeve. Power—Feb 18, 08. 2300 w. Feb 25. 2 figs. 1300 w. Mar 3, 3 figs. 2000 w. Mar 10. 6 figs. 3600 w. Each, 20c. A comparative study of results obtained by various experimenters, with the author's conclusions as to the methods to employ in future investigations.

Superheater Construction.

Superheater Construction and Operation. J. Rowland Brown. Power—Feb 25, 08. 3500 w. 20c. Gives a discussion of types, their location, connections and treatment, with formulas for computing area of heating surface.

WOODWORKING.

Circular Saws.

The Care and Repair of Circular Saws. James F. Hobart. Wood Craft—Mar, 08. 9 figs. 1300 w. 20c.

Wood Lathe.

The Machine Lathe in the Pattern and Woodworking Shops. H. N. Tuttle. Wood Craft—Mar, 08. 9 figs. 2000 w. 20c.

Wood Staining.

Modern Wood Staining Art and Practice. A. A. Kelly. Wood Craft—Mar, 08. 2200 w. 20c.

METALLURGY

COAL AND COKE.

By-Product Coke Ovens.

Notes on Canadian Retort Coke and Its Manufacture. Randolph Bolling. Eng News—Mar 5, 08. 7 figs. 4500 w. 20c. Describes the methods of producing metallurgical coke by Bernard and by Bauer retort-ovens for use as fuel in the blast furnace of the Nova Scotia Steel & Coal Co., at the Sydney Mines works.

The By-Product Coke Oven. William H. Blauvelt. Proc Am Soc M E—Mar, 08. 6 figs. 1200 w. 20c. Paper to be presented at the Detroit meeting (June, 1908) of the American Society of Mechanical Engineers.

The Von Bauer Coke-Oven System. Electrochem & Metal Ind—Mar, 08. 8 figs. 4000 w. 40c. Describes the latest type of this German retort coke oven, designed to effect the recovery of by-products.

Coke Oven Charging Machines.

Unique Electric Coke Oven Machines. Frank C. Perkins. Indus Mag—Feb, 08. 3 figs. 1400 w. 40c. Shows the construction and method of operation of a novel charging and discharging machine for gas plants;

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Coke Plant.

The Phillips Plant of the H. C. Frick Coke Co. A. F. Allard. Mines & Min—Mar, 08. 7 figs. 2300 w. 40c. Describes the arrangement, coke ovens, shaft construction, and the power plant utilizing coke oven heat.

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The Neill Process at Coconino, Arizona. James W. Neill. Eng & Min Jl—Mar 14, 08. 1000 w. 20c.

Smelting.

Copper Smelting at Mammoth Plant. A. S. Haskell. Min & Min—Mar, 08. 3 figs. 2400 w. 40c. Gives a general description of the enlarged plant of the United States Smelting, Refining & Mining Co., at Kennett, Cal.

GOLD.

Cyaniding.

Cyanide Precipitation and Clean-Up at the Portland, Colorado, Mill. J. M. Tippett. Min Jl—Feb 22, 08. 1300 w. 40c. Paper read before the Western Association of Technical Chemists and Metallurgists, Deadwood, S. D., Jan. 2-4, 1908.

Notes on Cyanide Treatment of Gold Ores. G. E. Bray. Min Jl—Feb 15, 08. 3700 w. Feb 22. 3000 w. Each, 40c. Paper read before the North Queensland Mining and Mill Managers' Association.

Notes on Preliminary Cyanidation Work. H. F. A. Riebling. Min Wld—Mar 7, 08. 1600 w. 20c. Extract from "West Chem & Met"—Oct, 07.

Electrolytic Refining.

The Metallurgy of Silver and Gold. J. W. Richards. Electrochem & Metal Ind—Mar, 08. 7000 w. 40c. Gives calculations involved in electrolytic refining process of both metals, and includes tables of their vapor tension.

Milling, Rhyolite, Nev.

The Montgomery-Shoshone Mill. P. E. Van Saun. Min & Min—Mar, 08. 2 figs. 2400 w. 40c. Gives a description of the equipment and methods of milling at the Bullfrog Reduction & Water Co., Rhyolite, Nevada.

Ore Dressing, Lake Superior Region.

Lake Superior Ore-Dressing Practice. L. S. Austin. Min & Sc Press—Feb 22, 08. 4 figs. 1200 w. 20c.

Slime Concentration.

Advances in Slime Concentration Practice. Edwin A. Sperry. Min Sc—Feb 13, 08. 3 figs. 3000 w. Feb 20. 5 figs. 3600 w. Feb 27. 2 figs. 3800 w. Each, 20c.

IRON AND STEEL.

American Iron Industry.

Conditions and Prospects in the American Iron Industry. Edwin C. Eckel. Eng Mag—Mar, 08. 1 fig. 4500 w. 40c.

Basic Iron Manufacture.

Making Basic Iron with High Sulphur Coke. Randolph Bolling. Ir Age—Mar 5, 08. 2400 w. 20c.

Blast Furnace Gas, Use of.

The Use of Blast Furnace and Coke Oven Gas. F. E. Junge. Ir Tr Rev—Jan 2, 08. 6 figs. 6600 w. 20c. Discusses recent German practice in the utilization of waste gases, and points on the economy resulting therefrom.

Blast Furnaces.

Recent Progress and Present Problems in the Blast Furnace Industry. John J. Porter. Ir Tr Rev—Jan 2, 08. 8500 w. 20c. Discusses the engineering and metallurgical problems connected with the operation of the blast furnace.

The Krupp Works at Rheinhausen. Ir Age—Feb 27, 08. 16 figs. 4000 w. 20c. Describes the blast furnaces, coke ovens, Bessemer and open-hearth steel works, blooming and finishing mills, of this modern German steel plant.

The New Blast Furnace at Wittkowitz, Moravia. Engr (Lond)—Feb 21, 08. 900 w. 40c.

The New Blast Furnace of the Shenango Furnace Co. at Sharpsville, Pa. Ir Tr Rev—Jan 2, 08. 4 figs. 2100 w. 20c.

The New Open-Health Furnace Building, Pennsylvania Steel Works, Steelton. Eng Rec—Feb 29, 08. 10 figs. 3100 w. 20c.

Briquetting Iron Ore.

The Briquetting of Iron Ore. Stahl u Eisen—Mar 4, 08. 1 fig. 4500 w. 60c.

The Scott Method of Sintering Fine Ores. Ir Age—Feb 20, 08. 3 figs. 1000 w. 20c. Describes method of putting fine ores and flue dust from blast furnaces into such shape as to make them suitable for charging into the furnace.

Coal Dust for Reverberatory Furnaces.

Coal Dust Firing for Reverberatory Furnaces. Charles F. Shelby. Eng & Min Jl—Mar 14, 08. 3600 w. 20c. States that the powdered ash introduces a number of complications and renders the value of the attachment of waste-heat boilers problematical.

Crop Ends and Segregation, Lessening.

The Compression of Semi-Liquid Steel Ingots. N. Lilienberg. Jl Frank Inst—Feb, 08. 13 figs. 14,000 w. 80c. Paper read before the Franklin Institute, Jan 27, 08. Describes means for making ingots solid and of proper structure, as well as for lessening the crop ends and segregation. Data in regard to power requirements and cost of plant are also given.

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The Red Dwarf Agency, Room M, 206 B'way, New York.

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American Builders' Review, San Francisco.
Canadian Municipal Journal, Montreal, Que.
Compressed Air, New York.
Concrete Engineering, Cleveland, Ohio.
Electric Railway Review, Chicago.
Engineering-Contracting, Chicago.
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Industrial Magazine, Park Row Bldg., New York.
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Duplex Phonograph Co., 303 Patterson St., Kalamazoo, Mich.

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Wemlinger Steel Piling Co., Bowling Green Offices, N. Y.

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Wemlinger Steel Piling Co., Bowling Green Offices, N. Y.

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Tool Steel:
Wm. Jessop & Sons, 91 John St., N. Y.

Towers, Steel:
Baltimore Cooperage Co., Baltimore, Md.

Tube Expanders:
Richard Dudgeon, 26 Columbia St., New York.

Vanadium:
Vanadium Alloys Co., 25 Broad St., New York.

Water Supply:
Rife Hydraulic Ram Co., R., 2100 Trinity B., New York.

Wire, Insulated:
Habirshaw Wire Co., 253 Broadway, New York.

Wood Preservatives:
Teredo-Proof Paint Co., 17 Battery Place, New York.

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Electric Drive.

Electric Driving of Steel Mills. Gerald J. Hooghwinkel. Ir Tr Rev—Feb 20, 08. 1200 w. 20c.

The Electric Driving of Rolling Mills. William T. Dean. Ir Tr Rev—Jan 2, 08. 7 figs. 5500 w. 20c.

Electric Smelting of Pig Iron.

The Electrical Smelting of Pir Iron. Horace Allen. Mech Engr—Feb 28, 08. 1600 w. 40c. Gives figures relating to the smelting of iron in electric furnaces, which show to some extent the variation in the electric current expended by the different systems and on classes of ore differing in quality.

Ferro Alloys.

Ferro Alloys and Metals Used in Steel Manufacturing. (Concluded.) W. Venator. Stahl u Eisen—Feb 19, 08. 4 figs. 1200 w. 60c.

Fin-Trimming Machine.

A New Machine for Trimming the Fins from Rolled Angle Sections. Stahl u Eisen —Feb 19, 08. 4 figs. 1200 w. 60c.

Nickel Steel.

The Determination of Nickel in Nickel Steel. O. Brunck. Stahl u Eisen—Mar 4, 08. 2000 w. 60c.

Phosphorus and Sulphur Determinations.

Determination of Phosphorus in Steel. M. Frank and F. W. Hendricksen. Stahl u Eisen—Feb 26, 08. 3000 w. 60c.

The Determination of Sulphur in Iron and Steel. H. Kinder. Stahl u Eisen—Feb 19, 08. 5 figs. 5000 w. 60c.

Rail Manufacture.

Explanation and Diagram Showing Cooling Curve of Steel. Ind Wld—Mar 9, 08. 800 w. 20c. Shows the decline in temperature by degrees, and the hours required to cool steel from fluid to non-workable solid, and how cooling periods would affect the T-rail.

Marking Rails to Indicate Their Relation to the Original Ingot. Eng News—Mar 12, 08. 1000 w. 20c.

Report on Plant, Schedule for.

Outline for a Report on an Iron and Steel Plant. Mines & Min (Denver)—Feb 28, 08. 1000 w. 20c. Gives schedule arranged by the faculty of the Colorado School of Mines.

Roasting Iron Sulphides.

The Wilfley Furnace. J. M. McClave. Eng & Min Jl—Mar, 08. 1 fig. 1000 w. 20c. Describes an improved furnace for roasting iron sulphides preparatory to magnetic separation.

ZINC.

Matte Smelting.

Matte Smelting at Ingot, California. W. B. Bretherton. Eng & Min Jl—Feb 29, 08. 6 figs. 7400 w. 20c.

Plant, Empire Zinc Co.

Canon City Plant of the Empire Zinc Co. Mines & Min (Denver)—Mar 6, 08. 1 fig. 1100 w. 20c.

Zinc in 1907.

A Review of the Zinc Industry. H. M. Burkey. Electrochem & Metal Ind—Mar, 08. 3800 w. 40c. Discusses the various phases of the zinc industry during the year 1907.

MISCELLANEOUS.

Electric Furnace Reactions.

Electric Furnace Reactions Under High Gaseous Pressures. R. S. Hutton and J. E. Petavel. Engg—Feb 21, 08. 20 figs. 2800 w. Feb 28. 26 figs. 11,000 w. Each, 40c. Abstract of paper communicated to the Royal Society. Gives results of a research to determine the correlation between the physical conditions and the chemical effects in the electric furnace, and more especially to ascertain the direct results produced by high gaseous pressures.

Metallurgy.

Practical Metallurgy.—I. Horace Allen. Pract Engr (Lond)—Feb 21, 08. 2000 w. 40c. Gives a comprehensive table showing the principal properties of various metals.

Refractory Materials.

Refractory Materials. Thos. Holgate. Engg—Feb 21, 08. 2400 w. 40c. Discusses recent investigations concerning the properties of refractory materials used in furnaces.

The Use of Chrome Ironstone as a Refractory Material. M. Simonis. Stahl u Eisen—Mar 4, 08. 1 fig. 900 w. 60c.

Smelters, Location of.

The Location of Smelting Works. Redick R. Moore. Eng & Min Jl—Mar 14, 08. 800 w. 20c.

Tungstic Acid, Determination of.

A New and Short Method for the Determination of Tungstic Acid in Tungsten Ores. John B. Eckley and George D. Kendall. Min Jl—Feb 22, 08. 2200 w. 40c. Paper read before the Western Association of Technical Chemists and Metallurgists, South Dakota, Jan. 2 to 4, 1908.

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MINING ENGINEERING

Coal.

Coal Mining in Northumberland by the Bord-and-Pillar System. George R. Dixon. Eng & Min Jl—Feb 22, 08. 3 figs. 2200 w. 20c.

Comparative Amount of Dust Made in Mining with Puncher Machines, Chain Machines and Hand Mining. B. F. Jones. Min & Min—Mar, 08. 1000 w. 40c.

Equipment for the Prevention of Mine Explosions. Wilbur S. Mayers. Eng & Min Jl—Feb 22, 08. 2000 w. 20c.

Lignite Briquetting in Germany. Robert Schorr. Eng & Min Jl—Feb 29, 08. 2100 w. 20c.

Plans for Mining a Flat Coal Seam. Audley H. Stow. Eng & Min Jl—Mar 7, 08. 2 figs. 2600 w. 20c. Describes an operating system that reduces cost of output to a minimum.

Recent Explosions in Coal Mines. H. M. Chance. Eng & Min Jl—Mar 14, 08. 2800 w. 20c.

The Bituminous Washery at Tyler, Pa. Edward K. Judd. Eng & Min Jl—Jan 29, 08. 4 figs. 1400 w. 20c. Describes electrically-operated plant in which the sulphur and ash contents in the coal are reduced nearly one-half.

The Coal Briquetting Plant at Bankhead, Canada. Ir Age—Mar 12, 08. 3 figs. 1600 w. 20c. Describes a new plant employing the Zwoyer process.

Colorado, Geology of.

The Historical Development of Colorado Viewed from a Geological Standpoint. T. A. Rickard. Min & Sc Press—Feb 22, 08. 3200 w. 20c.

Concrete in Mines, Use of.

Notes on the Use of Concrete in Mines. W. R. Crane. Con & Constr Engg—Mar, 08. 7 figs. 3400 w. 60c.

Copper.

Petrology of Evergreen, Colorado, Copper Deposit. E. A. Ritter. Min Sc—Mar 5, 08. 3 figs. 2900 w. 20c.

The Poderosa Copper Mine, Collahuasi, Chile. Robert Hawxhurst, Jr. Eng & Min Jl—Mar 7, 08. 1600 w. 20c.

The White Horse Copper Belt in the Yukon.—IV. William J. Elmendorf. Min Wld—Feb 22, 08. 1100 w. 20c.

Drilling.

A Hand Power Rock Drill. L. B. Orchard. Can Min Jl—Feb 15, 08. 3 figs. 1500 w. 20c. Describes a simple device for drilling by prospectors which can be used for raising or drifting.

Machine vs. Hand Drilling in Sinking on the Rand. Eustace M. Weston. Eng & Min Jl—Feb 29, 08. 2 figs. 3200 w. 20c. States that future labor shortage, attending industrial development and improved drill design will cause machine sinking to become preferable.

The South African Stope-Drill Competition. Eustace M. Weston. Eng & Min Jl—Mar 7, 08. 5 figs. 4000 w. 20c. Gives results proving conclusively the superiority of air-hammer drills as one-man drills.

Trial of Stoping Drills.—II. Engr (Lond)—Feb 14, 08. 6 figs. 1500 w. 40c.

Explosives.

Composition, Classification and Uses of High Explosives. W. H. Graves. Min Sc—Feb 20, 08. 2600 w. 20c. Discusses compounds and mixtures, nitroglycerine, dynamite, gun-cotton, Sprengel and safety explosives, detonators, etc.

Methods of Thawing Explosives. Eng Contr—Mar 11, 08. 1700 w. 20c.

Geology.

Geology.—II. James F. Kemp. Min & Min (Denver)—Mar 6, 08. 3600 w. 20c.

Gold.

Homestake Cost Data. C. W. Merrill. Min & Min—Mar, 08. 1 fig. 800 w. 40c.

Properties of the New York & Honduras Rosario Mining Co. Francis C. Nicholas. Min Wld—Feb 29, 08. 6 figs. 1700 w. 20c.

Iron.

Methods of Mining Iron Ore at Sunrise, Wyo. B. W. Vallat. Eng & Min Jl—Feb 22, 08. 6 figs. 1500 w. 20c. Describes replacement of steam shovel mining by the milling system.

The Economic Geology of Northern New York. Frank S. Mills. Eng & Min Jl—Feb 22, 08. 3 figs. 1700 w. 20c. Describes the valuable deposits of pyrites, graphite and iron ores in this region, which are neglected because of various unfavorable conditions.

Life-Saving Apparatus.

Modern Life-Saving Apparatus for Mines. Frank C. Perkins. Min Wld—Feb 29, 08. 7 figs. 2300 w. 20c.

Location of Claims.

The Location and Survey of Lode Mining Claims. Frank B. Goudy. Min Sc—Feb 20, 08. 2700 w. Mar 5. 1600 w. Each, 20c. Gives practical hints for laymen, prospectors and surveyors, as to mineral land acquisition, apex rights, location methods, surveying, solar observations, etc.

Mine Hoisting and Haulage.

Aerial Ropeway at a Colliery. Engr (Lond)—Feb 14, 08. 2 figs. 800 w. 40c. Describes an installation in which the ropeway carriers successfully pass at angles as high as 125 degrees.

Advantages of Electric Haulage. Fred Norman. Min & Min—Mar, 08. 2700 w. 40c. Compares the different kinds of haulage and states the conditions favorable to each; compressed air vs. electric locomotives.

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THE Railway Age

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New System of Handling and Dumping Mine Cars. Ind Mag—Feb, 08. 4 figs. 2500 w. 40c.

The Installation of the Steam Power Mine Plant. Otto Ruhl. Min Sc—Mar 5, 08. 2300 w. 20c. Gives notes relating to the boiler-house and the setting of foundations for boiler to insure maximum combustion efficiency.

Winding Ropes, Safety-Catches, and Appliances in Mine Shafts. Engg—Feb 14, 08. 7 figs. 2800 w. 40c. First article discussing the Royal Commission for Mines in the Transvaal.

Use of the Steam Accumulator in Mining. Jos. H. Hart. Min Wld—Mar 7, 08. 1400 w. 20c.

Mine Pumping and Drainage.

Notes on Some Tests and Results with an Oddie-Barclay High-Speed Mine Pump. Charles Latham. Min Jl—Feb 22, 08. 3 figs. 1800 w. Feb 29. 1700 w. Each, 40c. Paper read before the Mining Institute of Scotland.

Tapping Mine Water Under Great Pressure. Robert Sibley. Eng & Min Jl—Mar 14, 08. 5 figs. 1900 w. 20c.

Ore Deposition.

A Theory of Ore-Deposition. J. E. Spurs. Min & Sc Press—Feb 22, 08. 6000 w. 20c.

Diffusion as a Factor in Ore Deposition. Courtenay de Kalk. Min & Sc Press—Feb 15, 08. 2300 w. 20c.

Prospecting.

Prospecting. Fletcher Young. Mines & Mining—Feb 21, 08. 2400 w. 20c. Suggestion for prospecting from the Queensland Government Mining Journal.

Salt.

An Improved Method for Mining Salt.—II. Herman Frasch. Min Wld—Feb 22, 08. 6 figs. 2300 w. 20c.

The Saline Deposits of Carmen Islands. Edward H. Cook. Eng & Min Jl—Mar 14, 08. 5 figs. 8000 w. 20c.

Shaft Sinking and Timbering.

Improvements in Crossheads for Shaft Sinking. Eustace M. Weston. Eng & Min Jl—Mar 7, 08. 4 figs. 1200 w. 20c.

Shaft Timbering, Brakpan, Transvaal, S. A. Eustace M. Weston. Eng & Min Jl—Mar 14, 08. 2 figs. 1200 w. 20c. Describes the approximate method used for framing these timbers which are soon displaced by side pressure and fast hoisting.

Sinking a Five-Compartment Shaft on the Rand. Eustace M. Weston. Eng & Min Jl—Feb 22, 08. 5 figs. 3700 w. 20c. Describes how the difficulties caused by breakage of drill steel in hard rock were solved by slightly decreasing the air pressure.

Silver.

Daly-West Mine and Mill. Robert B. Brinsmade. Min & Min—Mar, 08. 4 figs. 4500 w. 40c. Describes the mill, methods of working the mines and of accounting, surface equipment, etc.

Tin.

Notes on Tin. Prof. A. Humboldt Sexton. Mach Engr—Feb 7, 08. 8 figs. 3400 w. Feb 21. 3 figs. 1600 w. Each 40c. III.—Reverberatory furnace methods. IV.—Refining tin.

Tin Mining in Tasmania. James B. Lewis. Eng & Min Jl—Mar 7, 08. 35 figs. 2400 w. 20c.

Ventilation of Mines.

The Conditions Influencing Mine Ventilation. Jos. H. Hart. Min Wld—Feb 15, 08. 2500 w. 20c.

Zinc.

Notes on Zinc.—I. Mech Engr—Mar 6, 08. 5 figs. 4800 w. 40c.

Practical Prospecting in the Missouri-Kansas District. Otto Ruhl. Min Wld—Feb 22, 08. 3 figs. 2400 w. 20c.

Zinc and Lead Deposits of Southwestern Missouri. F. Lynwood Garrison. Min & Sc Press—Feb 29, 08. 4 figs. 3600 w. Mar 7. 2 figs. 3900 w. Each, 20c.

MUNICIPAL ENGINEERING

REFUSE DESTRUCTION.

Chicago.

The Chicago Garbage Reduction Plant. Emmons J. Alden. Eng News—Mar 12, 08. 4 figs. 2600 w. 20c.

Westmount, Que.

The Westmount Municipal Electric Plant and Refuse Destructor. Can Engr—Mar 6, 08. 2 figs. 4700 w. 20c. Gives extracts from report of the consulting engineers to The Council of Westmount, Que.

ROADS.

Cost Data.

Gravel and Macadam Roads and Their Cost. G. C. Houston. Mun Engg—Mar, 08. 1700 w. 40c. From a paper before the Indiana Engineering Society.

Object Lesson Roads Built in 1906-07 by U. S. Office of Public Roads, with Data on Their Cost. Eng Contr—Mar 4, 08. 2600 w. 20c.

Tables for Estimating the Quantity of Materials and Cost of Gravel, Sand and Oil on Roads and Streets of Different Widths. Eng Contr—Mar 4, 08. 20c.

Pavements.

Good Pavements and How to Secure Them. J. W. Howard. Mun Engg—Mar, 08. 2000 w. 40c. From an address before the Civic Association of Morristown, N. J.

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Pavements in Salt Lake City, Utah. Mun Engg—Mar, 08. 8 figs. 1200 w. 40c. Gives photographs of streets showing the various kinds of paving materials used and their application to the conditions in that city.

Road Construction.

Present-Day Road Requirements in Town and Country. A. Brown. Surv—Feb 21, 08. 7000 w. 40c. Paper read before the Royal Sanitary Institute.

Roadway Widths and Excavations. George C. Warren. Mun Jl & Engr—Mar 4, 08. 4 figs. 2000w. 20c. Gives arguments favoring narrower roadways, with side and middle parking, with typical illustrations of such construction.

The Problem of Road Construction. H. S. Hele-Shaw and Douglas Mackenzie. Surv—Feb 28, 08. 2000 w. 40c.

Snow Removal.

The Economics of Snow Removal and a Suggested Improvement Over the Present Methods Used in New York. Richard T. Dana. Eng Contr—Mar 4, 08. 1200 w. 20c.

Street Cleaning.

Street Cleaning and Waste Disposal in New York. Eng Rec—Feb 22, 08. 4000 w. 20c. Gives data from report of a commission appointed to investigate and suggest a more effective system than that now in use.

Tar and Oil on Roads.

Experiments with Tar and Oil on the Highways of Rhode Island. Arthur H. Blanchard. Surveyor—Feb 28, 08. 4200 w. 40c.

The Use of Tar on Macadamized Roads. P. Caufourier. Génie Civil—Feb 15, 08. 3000 w. 60c. Discusses its influence on the cost of road maintenance.

SEWERAGE AND SANITATION.

Purification of Sewage.

Investigations on the Purification of Boston Sewage in Septic Tanks and Trickling Filters (1905-1907). E. A. Wilson and Earle B. Phelps. Tech Quarterly—Dec, 07. 19 figs. 26,000 w. 80c. Contribution from the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology.

Sewage Purification in Ohio. Eng Rec—Feb 29, 08. 3500 w. 20c. A review of the investigations conducted by the Ohio State Board of Health.

Run-Off from Sewered Areas.

The Numerical Determination of the Maximum Run-Off in City Sewer Systems.—I. Herr Range. Zeit Oest Ing u Arch—Feb 7, 08. 8 figs. 5000 w. 40c. Feb 14, 08. 11 figs. 5500 w. 40c.

The Run-Off from Sewered Areas. Eng News—Feb 27, 08. 2700 w. 20c. Describes apparatus and methods recommended by the Boston Soc. C. E., and gives references to literature upon the relation of run-off to rainfall in sewered districts.

Sanitation of Cities.

The Sanitation of Cities. E. Chardon. Tech Sanitaire—Feb, 08. 6000 w. 80c. Paper read before the Bordeaux congress of public works, Oct 9-12, 07.

Sewage Pumping Stations.

Electrically-Operated Automatic Sewage Pumping Station at Waltham, Mass. Bertram Brewer. Eng Rec—Mar 7, 08. 2 figs. 1100 w. 20c.

Lawrence Avenue Pumping Station, Chicago, Ill. Engr—Feb 15, 08. 10 figs. 2300 w. 20c. Describes a station for transferring sewage from the north side of the city to the river.

Sludge Disposal and Utilization.

The Use and Disposal of Sludge from Sewage Purification Plants. Gesund Ing—Jan 25, 08. 4500 w. 80c.

WATER SUPPLY.

Chemical Precipitation.

Chemical Precipitation of Water at St. Louis, Mo. Eng News—Feb 20, 08. 5400 w. 20c. Gives extracts from a recent Am. Soc. C. E. paper by Mr. E. E. Wall, Asst. Water Commissioner of the city.

Filtration.

High Relative Rates of Filtration with Slow Sand Filters. William B. Fuller. Eng News—Mar 12, 08. 1 fig. 1900 w. 20c. Describes a filter sand washing machine which affords a rapid method of cleaning slow sand filters.

Investigation of Collapse of Filter Roof During Construction at Lawrence, Mass. Sanford E. Thompson. Eng Rec—Feb 29, 08. 2 figs. 2700 w. 20c. From a paper read before the New England Water Works Association.

Sand Filters and Clear-Water Tanks for Small Water-Works. Engg—Mar 6, 08. 21 figs. 2000 w. 40c.

The Design of a Rapid-Sand Water Filtration Plant. H. A. Gehring. Cornell Civ Engr—Feb, 08. 2500 w. 40c.

The Development of the Mechanical Filter Plant. Philip Burgess. Eng News—Feb 22, 08. 4500 w. Mar 5. 5000 w. Each, 20c. From a paper read before the Ohio Engineering Society, Columbus, Feb 12, 08.

High-Pressure Supply for Fire Protection.

New York's Electrically-Operated, high-Pressure Water System for Fire Protection. El Wld—Mar 14, 08. 5 figs. 3200 w. 20c.

Run-Off, Diagram for Computing.

Diagram for Computing Run-Off by McMath's Formula. Samuel D. Bleich. Eng News—Feb 27, 08. 1 fig. 500 w. 20c.

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Typhoid at Washington, D. C.

Water Supply and Typhoid Fever at Washington, D. C. Eng News—Feb 27, 08. 18 figs. 2500 w. 20c. Extracts from a symposium on these and various related subjects presented before the Medical Society of the District of Columbia, Feb 19, 08.

Water Supplies.

An Unusual Water Supply for Industrial Purposes. Eng Rec—Feb 22, 08. 5 figs. 5300 w. 20c. Describes a large storm-water reservoir on the head waters of the Arkansas River, for storage of water required to supply a steel works at Pueblo, Colo.

Small Water Supplies. H. C. H. Shenton. Public Wks—Jan-Mar, 08. 24 figs. 13,000 w. 60c.

The Water Supply System at Los Angeles, Cal. Eng Rec—Feb 29, 08. 8 figs. 6100 w. 20c.

The Water Supply of Breslau. F. Beyschlag. Jl Gasbel—Feb 1, 08. 60c. Describes the city's system and discusses difficulties encountered in purifying the ground water used.

Water Works.

Combined Central Station and Water-Pumping Plant. El Wld—Feb 29, 08. 3 figs. 2700 w. 20c. Describes plant for city of 20,000 inhabitants, at Pine Bluff, Ark.

Water Works of Oklahoma City. Mun Jl & Engr—Mar 11, 08. 2 figs. 2000 w. 20c. Describes the rotary low-service pumps and direct-acting high-pressure pumps used, the sedimentation with coagulants, mechanical filtration, degree of purification obtained, etc.

Water Tower.

A Very Large Water Tower, Louisville, Ky. Eng Rec—Mar 7, 08. 7 figs. 2300 w. 20c. Describes a riveted steel cylinder, 50 ft. in diameter and 55 ft. in height, with a hemispherical bottom and a conical roof, supported on eight battered riveted steel columns 155 ft. high.

MISCELLANEOUS.

Public Baths.

Public Baths and Wash-Houses. T. W. Aldwinckle. Surveyor—Mar 6, 08. 2 figs. 6000 w. 40c. Paper read before the Association of Municipal and County Engineers.

RAILROAD ENGINEERING

CONSTRUCTION.

British East Africa.

The Uganda Railway, British East Africa. Herr Baltzer. Zeit d Bau—Feb 19, 08. 10 figs. 5000 w. 40c.

German East Africa.

The Dar-es-Salam Morogoro Railway. Rdmaster & Fore—Mar, 08. 13 figs. 2400 w. 20c. Describes a narrow-gage railway line in German East Africa beginning at the port of Dar-es-Salam on the Indian Ocean and extending west to Morogoro, a distance of about 130 miles.

Memphis, Tenn.

Memphis and State Line Railroad. Ry Age—Feb 28, 08. 16 figs. 1800 w. 20c.

POWER AND EQUIPMENT.

Car Wheels, Flat Spots on.

Allowable Length of Flat Spots on Car and Locomotive Wheels. E. L. Hancock. Ry Age—Feb 21, 08. 1 fig. 600 w. 20c.

Draft Gear.

Draft Gear. Ry & Eng Rev—Mar 7, 08. 4 figs. 3000 w. 20c. Extracts from a paper by A. Stucki, before the Railway Club of Pittsburg, Dec 27, 07.

Dynamometer Cars.

Dynamometer Cars. M. H. Roderique. Compt Rend Ing Civ—Nov, 07. 12 figs. 25,000 w. $1.20. Describes various types of these cars constructed in France and America.

Locomotives.

A Method of Repairing Cracked Piston-Valve Cylinders. B. P. Flory. R R Gaz—Feb 28, 08. 2 figs. 600 w. 20c.

Balanced Compound Locomotive with Superheater for the Pfaelz Railways. Ry Age—Feb 28, 08. 5 figs. 1700 w. 20c.

Cast-Iron Slide Valves for Locomotives. P Conte. Rev Gen Chem de Fer—Jan, 08. 5 figs. 2000 w. $1.20. Gives results of experiments made by the Compagnie d'Orleans on the successful substitution of cast iron for bronze in valves for simple locomotives.

Crane Locomotives: Buenos Ayres and Rosario Railway Company. Engg—Feb 21, 08. 1 fig. 500 w. 40c.

Express Locomotives—States Railroads of Sweden. R R Gaz—Feb 28, 08. 1 fig. 2500 w. 20c.

Four-Coupled Ten-Wheel Side-Tank Locomotive: L. B. and S. C. Railway. Engg—Feb 28, 08. 6 figs. 2400. 40c.

Four Cylinder Simple Locomotive, Great Northern Railway, England. Chas S. Lake. Am Engr & R R Jl—Mar, 08. 7 figs. 1400 w. 40c.

Handling Locomotive Supplies. E. Fish Ensle. Am Engr & R R Jl—Mar, 08. 2 figs. 7000 w. 40c. II.—Accounting.

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L. & S. W. Locomotive, No. 335. Engr (Lond)—Feb 7, 08. 3 figs. 1800 w. 40c. Describes a new English 4-cyl. simple locomotive with six coupled wheels.

Locomotive Smoke Stacks. W. E. Johnston. Am Engr & R R Jl—Mar, 08. 12 figs. 1100 w. 40c. Develops new formulae for stack diameters, using the data obtained in the Master Mechanics' tests of 1896, 1903 and 1906 as a basis.

Rack Locomotive for the Villa Nova De Gaya Railway, Portugal. Engg—Feb 14, 08. 5 figs. 1000 w. 40c.

Some Examples from Recent Italian Locomotive Practice. Mech Engr—Mar 6, 08. 4 figs. 2700 w. 40c.

Some Notes on Current British and Continental Locomotive Practice. Pract Engr (Lond)—Feb 7, 08. 1800 w. 40c.

Special Tank Locomotives for Wath Shunting (Gravity) Yard. Great Central Railway. Mech Engr—Feb 21, 08. 2 figs. 6000 w. 40c.

Ten-Wheel Baldwin Passenger Locomotive, St. Louis & San Francisco R. R. Ry & Eng Rev—Feb 22, 08. 3 figs. 1000 w. 20c.

The Brotan Locomotive. W. C. Dreher. R R Gaz—Feb 14, 08. 8 figs. 2000 w. 20c. Describes a high-economy Austrian locomotive boiler provided with a water-tube firebox.

The Locomotive from Cleaning to Driving. John Williams and Jas. T. Hodgson. Ry Engr—Mar, 08. 3 figs. 2300 w. 40c. XIV.—Lubrication.

The New Great Western Locomotive. 2 figs. 500 w. 40c. Gives details of a new 4-cyl. non-compound express locomotive for handling heavy traffic over difficult grades.

Motor Cars.

A Producer-Gas Motor Car. Prac Engr—Mar 6, 08. 3 figs. 1100 w. 40c. Gives some interesting particulars concerning the adaptation of this form of power production for motor-car work.

Locomotive for Railway Motor-Car; Lancashire and Yorkshire Railway. Engg—Feb 7, 08. 2 figs. 2600 w. 40c.

Passenger Coaches.

Passenger Coaches at the Milan Exposition, 1906. Herr Metzeltin. Z V D I—Feb 8, 08. 34 figs. 5000 w. 60c. Feb 15, 08. 34 figs. 3000 w. 60c.

Steel Passenger Equipment.—II. Charles E. Barba and Marvin Singer. Am Engr & R R Jl—Mar, 08. 1 fig. 4000 w. 40c. Discusses the arrangement of underframe members.

Rails.

Standard Track Sections. Ry Eng & M of Way—Feb, 08. 22 figs. 4000 w. 20c. Gives sections used by several railroads, with additional data not shown by the drawings.

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Roundhouses.

Roundhouses and Coaling Facilities on North American Railways.—I. Dr. Blum and E. Giese. Z V D I—Feb 8, 08. 16 figs. 5500 w. 60c.

Signaling.

Signaling of the East River Tunnels, New York R R Gaz—Feb 28, 08. 7 figs. 1500 w. 20c. Describes variations on previous practice in tunnel work which are employed.

Stations.

Large Railway Stations.—I. Engr (Lond) —Feb 14, 08. 11 figs. 3200 w. II. Feb 28, 5 figs. 2200 w. Each 40c. The first two of a series of articles on the large railway stations of Great Britain, in which the Paragon Station, Hull, and the station at Bradford are described.

Switches.

Electric Operation of Switches. C. Gufflet. Rev Gen Chem de Fer—Jan, 08. 11 figs. 12,000 w. $1.20. Describes the Bleynie & Ducousso system used in the Bordeaux-St. Jean yards.

Tank Car.

Standard 8,000-Gallon Tank Car. Ry Master Mech—Mar, 08. 2 figs. 1200 w. 40c. Gives details of a new design which includes a number of interesting features.

Terminal Problem, St. Louis, Mo.

Solving the Terminal Problem at St. Louis.—I. Ry Age—Feb 14, 08. 3 figs. 3,000 w. 20c.

Thrust of Wheels on Curves.

Lateral Thrust of Car Wheels on Curves. Ry & Eng Rev—Feb 29, 08. 4 figs. 2400 w. 20c. From a book, "The Car Wheel," published and copyrighted by the Schoen Steel Wheel Co.

Ties.

The Iron Sleeper. Engr (Lond)—Feb 21, 08. 21 figs. 3800 w. Feb 28. 21 figs. 1800 w. Mar 6. 2500 w. Each 40c. Paper by Dr. Ing. A. Haarmann, read before the Vereins Deutscher Eisenhüttenleute in December, 1907. An extended discussion on the use of iron and steel for railway ties.

The Problem of Track Support. Samuel E. Duff. Ry & Eng Rev—Feb 22, 08. 14 figs. 4200 w. 20c. Discusses the problem and describes a longitudinal form of steel support which has been successfully used for several years.

The Seasoning and Preservative Treatment of Hemlock and Tamarack Cross-Ties. Rdmaster & Fore—Feb, 08. 4 figs. 5000 w. 20c. Abstract of Circular 132, U. S. Department of Agriculture.

Train Lighting.

A New Train-Lighting Dynamo. El Rev (Lond)—Feb 21, 08. 8 figs. 1200 w. 40c. Describes a new train-lighting dynamo recently brought out by the Felton & Guilleaume-Lahmeyer Works.

Water Tanks.

Railroad Track Tanks. H. H. Ross. R R Gaz—Mar 13, 08. 11 figs. 3000 w. 30c.

Water Tanks on U. S. Railways. E. Giese. Z V D I—Feb 22, 08. 17 figs. 4000 w. 60c.

STREET AND ELECTRIC RAILWAYS.

Conduit System.

The Conduit System of Electric Tramway Construction and Recent Improvements. Fitz Roy Roose. Elec Engr—Mar 6, 08. 19 figs. 2000 w. 40c. Concluded. Describes the side-slot system.

Electrically Equipped Roads.

The Street Railway System of San Diego, Cal. St Ry Jl—Mar 14, 08. 5 figs. 2200 w. 20c.

Tramway and Power Developments in Porto Rico. St Ry Jl—Feb 22, 08. 11 figs. 2800 w. 20c.

Electrification of Railways.

Electrification of Railways.—II. Dr. Gisbert Kapp. Elec Engr—Feb 7, 08. 12 figs. 2400 w. 40c. Lecture delivered before the Royal Institution of Great Britain, Jan 25.

The Electrification of the Suburban Zone of the New York Central and Hudson River Railroad in the Vicinity of New York City. William J. Wilgus. Proc Am Soc C E—Feb. 08. 58 figs. 10,000 w. 80c. Paper read before the Am. Soc. C. E. Mar 18, 08.

Subway Car Design.

Report on Subway Car Design in New York. St Ry Jl—Feb 29, 08. 9 figs. 4600 w. 20c. Abstracts of the report of Bion J. Arnold to the Public Service Commission.

Types of Rapid Transit Car for Maximum Service. Eng News—Mar 5, 08. 1 fig. 3300 w. 20c. Resume of a report by Bion J. Arnold to the Public Service Commission of New York.

Track.

A Comparison of Substructures for Tracks in Streets. H. L. Weber. Elec Ry Rev—Jan. 25, 08. 3 figs. 1900 w. 20c. Gives comparative costs of wood and steel ties on concrete bases.

Bonding. E. Goolding. Tram & Ry Wld —Jan. 2, 08. 3 figs. 1400 w. 40c. Gives diagram for determining the approximate resistance of bonded track.

Cost of Constructing Street Railway Track with Rubble Concrete Base at Ft. Wayne, Ind. Eng Contr—Mar 11, 08. 1 fig. 600 w. 20c.

Proposed Track Changes at 96th Street, New York Rapid Transit Subway. Eng Rec —Feb 29, 08. 1 fig. 1700 w. 20c.

Track Construction in Streets for Interurban Service. Thos. B. McMath. Mun Engg—Mar, 08. 1000 w. 40c. From a paper read before the Indiana Engineering Society.

Track Reconstruction in San Francisco. St Ry Jl—Jan. 18, 08. 13 figs. 1300 w. 20c.

THE ENGINEERING DIGEST

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HAND BENDING TESTS OF MATERIALS

FROM "THE IRON AGE"

Tensile tests alone are inadequate to indicate the true value of material in actual working practice; when a material will have to sustain moving stresses, it is evident that to test it merely by static loads is insufficient and a dynamic test is required. The most favored and promising method of testing in this way is by bending a piece in opposite directions, counting the number of alternations necessary to fracture it. In Prof. Arnold's machine the metal is alternately strained beyond the elastic limit in each direction.

Capt. H. Riall Sankey, who in conjunction with J. Kent Smith has done such good pioneer work on vanadium steels, has devised a workshop testing machine, which was described in Engineering (London) some months ago. By means of this instrument, in which a test piece is bent alternately backward and forward through a given angle, results are obtained very similar to those given by Arnold's machine.

The machine is illustrated in Figs. 1 and 2. Its general character may be best understood by a reference to Fig. 2. It consists essentially of a bedplate to which is secured the small vise a. One end of the test piece is secured in this vise, while the other end is fastened in a similar vise, b, mounted on the end of a movable frame. The specimens used are ⅜-in. square and 4 ins. long. A gage is used in placing them in position, so that the piece being bent is the same length in all cases. The specimen is then bent through a definite angle by means of the handle e, first in one direction and then in the other, until it breaks. In Fig. 2, it may be seen that the movable frame swings about d, and that the pressure exerted is transmitted through the springs f. The compression of these springs measures the load applied to the specimen, and as the springs compress the handle e swings around the pivot d. The displacement of the handle is utilized for the drawing of an autographic diagram, which shows the maximum force applied on each alternate bend of the specimen, and also the total number of bends before failure occurs.

Sample diagrams are shown in Fig 3. The cards, circular in form, fit down upon the ratchet wheel k, with which they are concentric. A pencil seen in Fig. 1 and indicated at g, Fig. 2, traces a circular arc on the card when the lever is pushed over. On the return bend the ratchet wheel is pushed over one tooth, so the pencil traces another arc. Each arc on the diagram represents a bend in each direction, so that the total number of bends is equal to twice the number of arcs on the card. The concentric circles shown on the diagram represent equal increments of load on the specimen. It may be seen that much more effort was required when the right hand diagram, Fig. 3, was taken, than with the left hand one. The cards form a permanent record of both the stiffness of the material and the number of bends required to fracture it.

Tests have been made upon a series of carbon steels and upon three samples of steels containing 0.04, 0.3 and 0.5% phosphorus respectively. In the case of the phosphorus steels, tensile and Wöhler tests gave unsatis-

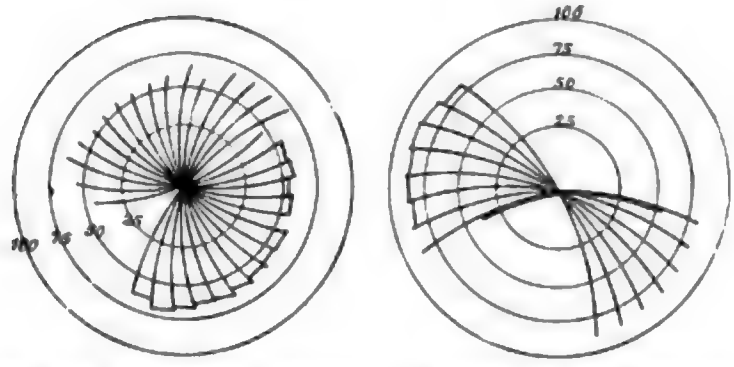

FIG. 3. SPECIMEN DIAGRAMS MADE BY THE TESTER.

neers. A comparison of the hand bending with the ordinary tests shows that numerical figures are obtained by means of which the quality of the steel can be compared in the same manner as by the ordinary tensile test and the impact test combined. They are given in the following table, the tests being on forged unannealed steels:

Number.	Carbon.	Number of bends.	Average bending effort, ft.-lbs.	Energy absorbed.
1	0.13	43.5	61	5,300
2	0.18	30.5	83	5,060
3	0.25	21.2	72	3,050
4	0.47	23.5	92	4,320
5	0.72	12.2	130	3,170
6	0.87	5.1	170	1,730
7	0.95	4.3	157	1,300
8	1.31	3.2	124	800

The bending machine also produces a fracture which varies very considerably with the quality of the steel, a variation greater than with an impact test, and much greater than in the case of a tensile test. This is illustrated in the following table:

No.	Carbon.	Fracture impact test.	Fracture bend test.
1	0.13		Silky.
1	0.18	Very fine granular.	Silky.
3	0.25	Very fine granular.	Granular and silky.
4	0.47	50% very fine crystalline.	Fine granular.
5	0.72	Fine crystalline.	Granular & Crystalline.
6	0.87	Very fine granular.	Medium crystalline.
7	0.95	Very fine granular.	Fine crystalline.
8	1.31	Crystalline.	Fine crystalline.

Captain Sankey's simply constructed, readily operated machine seems to have demonstrated its efficiency and to be worthy of adoption on an extended scale for practical use.

THE RUSTING OF IRON

A RÉSUMÉ OF RECENT RESEARCHES INTO THE THEORY OF CORROSION

CONDENSED FROM "ENGINEERING"

In spite of all investigations the chemist is not yet in a position definitely to tell the engineer how iron rusts, and which kinds of iron are particularly subject to rusting. The question is not one of exclusively chemical nature, with which the engineer need not concern himself. Boiler corrosions are sometimes ascribed to inferior materials, said to favor rusting. The charge is not rarely made on insufficient evidence, and it cannot be said that the papers, which electrochemists have of late published on the passivity of iron and cognate features have helped the engineer much.

It is generally conceded that iron will not rust in dry air, and that it will rust in moist air. Since in the latter case a hydrate is formed, and not one of the anhydrous oxides, both the oxygen and the water are concerned in the rusting. But the question arises whether the impurities of the air—the carbonic acid, in the first instance, then the nitrogen compounds—play any essential part. Nobody disputes that impurities such as sulphurous acid are injurious to the iron. It is the carbonic acid about which the fight has been renewed. In October, 1905, Professor Wyndham Dunstan, Dr. H. A. D. Jowett, and Dr. E. Goulding, of the Imperial Institute, brought before the Chemical Society an account of researches on the rusting of iron. In 1905 most English chemists believed, on the strength of the investigations of Crace Calvert, of 1871, and of Crum Brown, of 1888, that iron rusted through the combined action of the oxygen and carbonic acid of the air in the presence of liquid water, the iron carbonate first formed being gradually converted into a ferric hydroxide, or brown rust, by the atmospheric oxygen. Dunstan maintained that iron, oxygen, and liquid water were alone necessary for rusting, and that car-

bonic acid played a subordinate part; he also believed that the reaction presupposed the intermediate formation of hydrogen peroxide. These conclusions were soon attacked by Dr. G. T. Moody, of the Central Technical College, South Kensington, who asserted that the presence of carbonic acid was essential for the rusting process in air and water, and that hydrogen peroxide had nothing to do with the phenomena.

Dunstan and his collaborators believed in the importance of hydrogen peroxide. They were unable to prove its presence, but suggested that it was a necessary intermediate product, being probably formed by decomposition of water. They found that none of the following agents had any visible action as long as the temperature was constant: dry gases, moist oxygen, moist oxygen and carbonic acid, moist oxygen and ammonia, and moist carbonic acid (CO_2); but that moist oxygen, as well as moist oxygen together with CO_2, produced rust when the temperature fluctuated so that liquid water was condensed on the iron. Calvert does not appear to have observed this influence of temperature fluctuations and of the moisture deposit, which, however, was fully recognized by I. Spennrath, whose researches seem entirely to have been overlooked by British and also by American chemists.

In 1895 Spennrath presented to the Verein zur Befoerderung des Gewerbefleisses a chemical and physical study of anti-rust paints, in which he first studied the rusting problem. He concluded that rusting required the combined action of oxygen and liquid or condensed water. Iron remained bright for years under water deprived of its oxygen by boiling, and remained also bright when suspended over water or in saturated steam, provided the temperature was not lowered to condense water on the metal. Neither was iron attacked in the boiler, because the oxygen would be removed by the boiling, except at the water-line. Therefore, to keep rust out of a boiler which is only to be used temporarily, the boiler should be filled and boiled up. Spennrath further pointed out that gasholders did not rust inside, because the oxygen was kept out. The presence of CO_2 was not necessary to rust formation; for iron did not rust when suspended over caustic soda, which would absorb the CO_2, as long as a condensation of water on the iron did not take place. Water and carbonic acid together produced rust, however, because the acid dissolved some iron, which was further oxidized by the oxygen of the air. The drops falling from iron roofs in textile works, Spennrath pointed out, were colorless, but they gave rust-spots because the dissolved ferrous carbonate was afterwards oxidized. Iron rusted faster in the presence of acids and of many salts.

Moody's objection to the arguments of Dunstan is that Dunstan and others did not take sufficient care in their experiments to exclude carbonic acid, which is an extremely difficult task. Moody found no rusting whatever when air was bubbled for five weeks through the distilled water covering a piece of bright iron, provided the air was passed through and over caustic potash and soda-lime. When afterwards air, merely sucked through a tower containing pumice-stone moistened with distilled water, was admitted, tarnishing of the iron set in in six hours, followed by copious rusting. This experiment of Moody's does not really prove that carbonic acid is the primary rusting agent; it might be anything in the air absorbed by caustics. In other experiments he demonstrated that the absorption of oxygen by iron exposed to air and water is almost entirely stopped if the carbonic acid of the air is removed. He also analyzed rust from the unpainted interior of iron flushing-tanks, which had not been scraped for years. The rust was brown on the outside, almost black on the inside, and contained, for example, 56% of the iron as ferric oxide, 33% as ferrous oxide, and 11% as ferrous carbonate, in addition to some calcium carbonate. With hydrochloric acid this rust effervesced, evolving carbonic acid, and when exposed to the air the rust lost in eight days half of its ferrous oxide and of its carbonate by further oxidation to ferric oxide. The persistency of the ferrous oxide in the rust Moody ascribes to the circumstance that rusting iron continuously liberates hydrogen at its surface. He determined this hydrogen in other experiments, in which he dissolved iron in carbonic acid and water; the solution was clear and colorless, but turned turbid when air had access. In hydrogen peroxide, free of acid iron did not rust at all.

In March last year Moody showed other experiments before the Chemical Society, to demonstrate that carbonic acid is essential to rusting. French nails were placed in distilled water—some with heads upward, some vertical, some inclined; about 1⅛ in. of distilled water stood over the nails. In twenty-four hours brown particles began to settle on the heads and also on the upper portions of the inclined nails, while the vertical portions remained bright. When filter paper was placed above

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the nails, the rust would collect on the paper—not on the iron—showing that rust is an oxidation product of dissolved iron.

We now turn to the electrolytic theory of rusting, to which W. R. Whitney gave definite shape in a paper read before the American Chemical Society in 1903. This thesis goes back to the electrolytic solution tension theory of Nernst. According to Nernst, a solid dissolves in a liquid just as it evaporates in a gas. The vapor tension makes the solid evaporate, and the solution tension makes it dissolve, until the osmotic pressure of the saturated solution formed stops further dissolution. Metals differ from other substances in so far as they only pass into solution in the shape of positively charged irons. We speak, therefore, of electrolytic solution tension in the case of metals. When a metal is dipped into pure water, it emits some positive ions, which charge the water positively, while the metal itself becomes negatively charged. At the same time electrostatic attraction is set up between the two charges; this force opposes the solution tension. If the two forces are in equilibrium, the dissolution is arrested, and this will often take place before appreciable quantities of the metal have been dissolved, because the electrostatic capacity of the ion is enormously large. If, however, the solution tension is strong, then any other positive ions, already contained in the water—which is always slightly dissociated into the ions H. and OH'., the dot standing for positive, the dash for negative ions—are driven from the solution towards the metal, a potential difference is set up, a current flows, and the dissolution of the metal proceeds while hydrogen is liberated.

This latter case will better be understood if we imagine a metal like iron dipping into a salt solution like copper sulphate. The sulphate contains copper ions; the emitted iron ferro ions drive these copper ions to the iron plate, where they are deposited. Everybody knows this; what we are apt to forget is, that just as much iron—in electro-chemical equivalents—is dissolved as copper is deposited. Going back to one metal and pure water, we find that potassium most readily dissolves in water (with almost explosive energy), because its solution tension is very great, so that a strong potential difference is established, and a powerful generation of hydrogen is observed. Iron dipping into pure water finds there only very few hydrogen ions. Yet Whitney stated that, in the course of weeks, bright iron dissolved in pure water freed of its air by boiling; the clear solution became cloudy afterwards on admitting air, and iron hydrate was deposited. That any dissolved iron would first be in the ferrous condition—colorless when diluted—and that it would not become visible before its oxidation to ferric oxide, is undisputed. But Dunstan, repeating Whitney's experiment, did not find that any iron was dissolved by pure water, nor that any hydrogen was evolved, which the dissolution of the iron should have liberated. Whitney further pointed out that a trace of carbonic acid would act catalytically, so to say, by causing the dissolution of an unlimited quantity of iron.

Whitney's views are supported by Dr. Allerton S. Cushman, assistant director of the United States Department of Agriculture, who last year presented a report—published as Bulletin 30 of that department—to the American Society for Testing Materials, meeting at Atlantic City. According to Whitney, substances splitting off hydrogen ions—e. g., acids—should promote rusting, and substances splitting off hydroxyl ions—e. g., bases—should inhibit it. Cushman emphasizes this point. Broadly speaking, experience favors this view, for we know that acids corrode, and alkalies preserve iron. But the question is not so simple; strong alkalies attack iron. It may appear strange, on the other hand, that oxidizing agents, like chromic acid and potassium bichromate, should prevent rusting. Dunstan says they do so, because they destroy the hydrogen peroxide. Moody denies this, and Cushman ascribes the protection to the passivity induced by the bichromate.

The passivity problem is too wide to be discussed at length. Some metals turn passive when they cover themselves with a layer of impervious oxide. Iron rust, unfortunately, is not impervious, and in many cases there is no visible oxide film, and we may merely have to deal with a gaseous film of oxygen, or also of hydrogen. Cushman dipped a rod of iron for hours in bichromate solution of 5 or 10%; the iron remained apparently unchanged, but it turned passive. When afterwards immersed in a solution of copper sulphate, the rod did not at once take a deposit of copper, as it should in the active state; but the immersion in the sulphate had to be repeated at least six times before any deposition of copper was noticed.

As, further, iron does not rust when under bichromate solutions, even when air is passed through the boiling solutions, Cushman recommends the addition of a small quantity of potassium bichromate to the feed-water in order

to prevent rusting of boilers. A solution of 1/160 normal would suffice, which would mean 1 lb. of bichromate for 1,500 gals. of water. In view of cases of rapid corrosion of the steel boiler tubes of vessels fitted with turbine engines, he considers such a precaution necessary; the customary protection by means of zinc strips is difficult to apply in these boilers. This destruction within a few months may be due to the influence of volatile acids, as Spennrath already recognized. Volatile organic acids, impinging upon the bronze blades of the turbine, dissolve some copper; those copper ions would hasten the dissolution of the iron which would be very slow and soon stopped, as we pointed out, in pure water.

In order to demonstrate that the ions, the ferro and the hydroxyl ion, are really active in the rusting processes, Cushman prepared his "ferroxyl," a gelatinized mixture of phenolphthalein and ferro-cyanide of potassium. Wires and strips of sheet metal embedded in this ferroxyl became marked with irregular blue and red spots; the blue is said to be due to the reaction between the ferro-ion and the ferrocyanide under formation of Turnbull's blue, the red due to the reaction of hydroxyl with phenolphthalein. One does not feel certain that this somewhat coarse test really marks the distribution of the ions. But there is no doubt that rusting is much promoted by electrolysis. Dunstan disputed that the rusting is primarily electrolytic in nature, but he found, as was to be expected, that iron would not rust in many salt solutions when wrapped with zinc foil (in which couples the iron is the electro-negative element), and would rust when wrapped with platinum (towards which iron is positive).

The researches of William H. Walker, Anna Cederholm, and Leavitt N. Bent, of the Massachusetts Technical Institute, presented to the American Chemical Society last autumn, follow broadly the same lines as Cushman's report. Like Cushman, they make use of phenolphthalein and potassium ferricyanide in order to demonstrate the electrolytic nature of the iron corrosion. But they also supply some further interesting experiments. We mentioned that Dunstan was unable to confirm Whitney's observation that iron would dissolve in water entirely free from oxygen or carbon dioxide. When the water is concentrated to a few drops, however, the iron test is successful, according to Walker and his fellow-workers. In the presence of a depolarizing agent, such as hydroxylamine, the very feeble solvent action of water on iron is continuous. Oxygen itself can act as a depolarizer, and the rapidity with which the rusting proceeds is found to be a direct function of the partial pressure of the oxygen above the water. In acting as depolarizer, the oxygen combines with the hydrogen liberated during the dissolution of iron. The oxygen must itself be dissolved in the water; under these circumstances, hydrogen peroxide may be formed, and hydrogen peroxide may incidentally, though not necessarily, be one of the intermediate products of the rusting process. On this point, and also on the part played by carbonic acid, Walker is, therefore, not in accord with Moody. The latter maintains that iron will not rust in water if all access of the carbon dioxide of the air is excluded. But he performed his crucial experiments in vessels of ordinary glass, which becomes slightly alkaline through the action of water on the glass. Now alkali inhibits or retards the rusting of iron. Repeating Moody's experiments in vessels made of Jena glass, Walker observed that iron under water rusted almost as fast as when exposed to the air. Walker also questions Moody's experiments with chromic acid, which, it is pointed out, renders iron more persistently passive than Moody seems to have assumed.

The researches of Wolf Müller and Johann Königsberger chiefly concern the passivity of iron and other metals. They had, up till recently, chiefly relied on optical tests. They found that iron mirrors, dipped into various electrolytes, showed practically the same reflective power both in the active and in the passive state, and they concluded that the passivity could not be due to any assumed film of oxide on the iron. Haber, Goldschmidt and W. Maitland, C. McCheyne Gordon and F. E. Clark, and others, objected that such iron mirrors would always be in the passive state before being immersed, and would remain so in Müller's electrolytes. Müller and Königsberger, last autumn, published further experiments, pointing out that the potential differences of their iron electrodes certainly proved that they experimented both with active and with passive iron; yet the reflective powers were the same.

Among others who advocate the electrolytic theory of rusting and who deal with passivity of iron we may mention H. L. Heathcote, whose studies were brought before the Society of Chemical Industry last year.

Since different sorts of iron are not electrically neutral to one another, and as local couples are set up in ordinary iron, which al-

ways contains various impurities, Cushman suggests that we should use the purest iron and avoid galvanic contact with other metals, so far as possible. The practical range of this possibility is, however, very limited, and the recent experiments—still being continued—of A. Schleicher and G. Schultz, of the Technical High School at Munich, show that the matter cannot be put so broadly.

Schleicher and Schultz suspend plates of iron in water, and couple them with resistances and a galvanometer in the way which is usually applied for conducting polarization tests. The curves which they thus obtained were all smooth. When two somewhat rusty iron plates were coupled, the one plate would become covered with gas bubbles, while turbid striae began to descend from the other; the former plate corresponded to the (positive) carbon, the latter to the (negative) zinc of a voltaic couple. After a while, bubbles and striae could be noticed on both plates. When the striae from the two opposite plates began to mix with one another, the potential difference vanished. With this couple the potential fell continuously, rapidly at first, during the 90 minutes of an experiment; exactly the same phenomena were again observed after the plates had been dried in the air. When two bright plates, cleaned with emery paper and a dry cloth, were coupled, the initial potential difference had a lower value; it decreased, became negative, and rose again at a fairly uniform rate for the three hours of the experiment. The general appearance of the plates and water was the same as in the first experiment; during the reversal of the polarity, gas-bubbles were not seen on either plate. One bright plate coupled with a rusty plate gave a curve of first decreasing and then slowing rising potential, attaining a higher than the initial value; at first only the bright cathode showed the formation of striae. On renewing the experiment several times with the same plates, re-polishing the cathode and drying the anode, the same kind of curves resulted; but the observed initial and the minimum potentials showed higher values. The rise of potential would particularly be marked and steady on open circuit, which indicates that a depolarization takes place in the cell; on shaking the liquid, the potential would drop off. Finally, the potential difference would always vanish; the liquid was then very turbid, and the bright cathode, which had turned greenish during the experiment, would show some spots of rust.

These observations can be summed up as follows: As long as there is no potential difference between the two plates, both plates are equally attacked; with varying potential difference the one plate is more changed than the other. The maximum potential difference observed was 0.36 volt; the corresponding current intensity, 0.00018 ampere. When plates of carbon and bright iron were coupled, the carbon became the anode, the potential set in rather high, and rose on open circuit continuously to 0.77 volt in 24 hours; after five more hours, the water had become very turbid, and the galvanometer had gone back to zero. Plates of wrought iron rusted more when alone than when coupled with carbon plates; plates of cast iron behaved similarly, but showed smaller potential differences. In couples consisting of one wrought-iron and one cast-iron plate, the latter was chiefly attacked; finally, however, both were found rusted. In water containing carbonic acid, cast-iron shavings and grains were more rapidly dissolved than wrought-iron particles of the same kind.

These experiments indicate both that differences in the behavior of different kinds of iron may disappear on prolonged exposure, and that some other factors have to be considered. From the researches of G. T. Beilby we know that the same metal, whether pure or impure, behaves differently in mechanical, physical and chemical respects, when in the soft and when in the hard phase. C. F. Burgess and Engle have dissolved sheet irons in diluted sulphuric acid and hydrochloric acid, and found that pure electrolytic iron dissolved more quickly than cast iron and steel. After being heated up to 1,000° C. the electrolytic iron fell in with the others; but this heating altogether changed the order of the corrodibility of the various irons. Fawsitt has pointed out that the electrolytic iron is readily dissolved because it presents a large crystalline surface. Surface condition and mechanical treatment are no doubt important features.

For the engineer, delicate laboratory determinations of potential differences have little value. Such determinations do not tell him how the iron will really behave when riveted up in his boiler or building. We cannot decide whether the rusting is primarily electrolytic or not. It is certain, however, that small potential differences can, in the course of time, give rise to very bad electrolytic corrosion. Even the iron in ferro-concrete is exposed to such corrosion. The engineer will therefore do well to use chemically and mechanically homogeneous iron in structures in which rusting has to be guarded against.

THE DESIGN OF REINFORCED-CONCRETE CHIMNEYS

By C. PERCY TAYLOR, CHARLES GLENDAY and OSCAR FABER

CONDENSED FROM "ENGINEERING"

This subject has had the attention of the authors for some time past, both as regards materials and calculations.

As to the concrete, tests of a 1 to 3 mixture of washed river sand and rotary-kiln cement show that it does not deteriorate under the action of the dry heat to which it is subjected in an ordinary flue, and that a crushing stress of 600 lbs. per sq. in. may be safely assumed for purposes of calculation.

Assuming (1) that the concrete is incapable of withstanding any tensile stress, (2) that $E_s = 15\ E_c$, (3) that the strain diagram is a straight line, (4) that the maximum compression in the concrete (measured on the mean circumference) is 600 lbs per sq. in., and (5) that the maximum compression and tension in the steel are 9,000 lbs. per sq. in. and 12,000 lbs. per sq. in., respectively, it is easily seen that the distance from the center of the chimney to the line of zero stress = 0.143 r, where r = mean radius of the shell in inches.

Also, distance of center of compression from line of zero stress = 0.681 r (from center of chimney = 0.824 r), and distance of center of tension from line of zero stress = 0.924 r (from center of chimney = 0.781 r).

Since all the forces are in equilibrium, the excess of pressure over tension must be due to the height of the chimney, W (in lbs.), above the section under consideration, and analysis shows that in consequence

$$t_c = (W/1{,}100\ r) + (8{,}566\ t_s/1{,}100) \quad . . (1)$$

where t_c and t_s are respectively the thickness in inches of the concrete and of an imaginary steel shell of mean radius r, having a sectional area equal to the actual area of the reinforcing bars.

From the stress analysis in a section we can obtain from the conditions of equilibrium expressions for the thickness of the concrete and the area of the steel in terms of weight, wind moment, and the mean radius of the shell, viz.:

$$t_c = (M/40{,}256\ r^2) - (W/48{,}855\ r) \quad . . (2)$$

in which M = moment in inch-pounds of the wind about the section under consideration.

The total sectional area of steel required = $2\ \pi\ r t_s$, or, from (2),

$$(M/6{,}408\ r)\ (W/7{,}776) \text{ sq. ins.} \quad . . . . . (3)$$

Total thickness of chimney, t = (1) + (2)

$$= (M/4{,}582\ r^2) + (W/1{,}372\ r) \text{ ins.} \quad . . . . (4)$$

As to the stress ratio giving the most economical results, it would at first sight seem that this would be obtained when both steel and concrete are stressed to their maximum safe limits—say, 600 lbs. per sq. in. for the concrete and 16,000 lbs. for the steel. While this is true for the concrete, a lower stress than 16,000 lbs. in the steel often gives the most economical results.

Thus, for the upper 120 ft. of a parallel chimney of 6 ft. internal diameter, with a constant maximum compression of 600 lbs. per sq. in. in the concrete, and assuming the concrete to cost $5.08 per cu. yd. and the steel $58.32 per ton of 2,240 lbs., the total costs with different steel stresses are as follows:

Stress in steel, lbs.	Thickness of shell, ins.	Steel, lbs.	Concrete, lbs.	Total cost.
10,000	2.6	10,500	69,500	$398.52
12,000	5	5,660	146,340	379.08
16,000	8	2,900	247,100	456.84

It is thought that 5 ins. is the minimum thickness which can be satisfactorily molded, and at the same time afford sufficient covering for the steel. In calculations based on a 600/12,000 stress ratio the shell thickness may come out considerably under 5 ins. In this case a 600/14,000—or even a 600/16,000—ratio should be used, to insure that the thickness shall be at least 5 ins.

In a theoretically correctly proportioned chimney the shell thickness should taper gradually from top to bottom. In practice, however, the expense involved for shuttering renders it nearly prohibitive, and two different thicknesses only are therefore generally used, with a break or offset about one-third up.

The data regarding an American chimney which recently failed are: Height from point

of failure to top, 131 ft.; internal diameter, 11 ft.; shell thickness, 6 ins.; area of steel (16 — 1¼ × 1¼ × 3/16-in. T-bars), 7.04 sq. ins. From these values total weight on section of failure = 18 × 131 × 150 = 353,700 lbs. Bending moments due to wind = 25 × 12 × 131 × 65.5 × 12 = 30,960,000 in. lbs.

(Wind pressure taken as 50 lbs. per sq. ft., or 25 lbs. per sq. ft. of vertical projection of chimney.)

Substituting these values in (4), we find that t = 5.16 ins., and from (3) the area of steel = 24.5 sq. ins. [For a 600/16,000 stress ratio, $t = (M/2{,}866\ r^2) + (W/1{,}419\ r)$, and area of steel = (M/8,685 r) — (W/10,230); using these formulas, t works out at 5.88 ins., and area at 17.2 sq. ins.]

From these calculations it is seen that while the thickness of concrete was ample, there was not nearly enough steel to insure safety, and that this deficiency in steel greatly increased the pressure on the concrete by throwing the line of zero stress away from the center of the chimney, and thus leaving a very small proportion of the section in compression.

As nearly as can be calculated the maximum stresses developed under the 50-lb. wind pressure were 750 lbs. per sq. in. on the mean circumference, 810 lbs. on the extreme outer edge of the concrete, and 31,000 lbs. per sq. in. in the steel. From this it is evident that the failure of this chimney cannot be said to cast any reflection upon the use of properly designed ferro-concrete for such structures. On the contrary, given sound design coupled with good workmanship, ferro-concrete chimneys have in many cases sufficient advantages over other types to insure their use in all but exceptional cases. They possess special merits where: (1) space is limited; (2) foundations are bad; or (3) the height is great in proportion to the diameter.

NEW PROCESSES FOR THE PURIFICATION OF DRINKING WATER

FROM RECENT ARTICLES IN "ENGINEERING NEWS," "MUNICIPAL ENGINEERING" AND "ELECTRICAL ENGINEERING"

Considerable matter has appeared in recent technical publications, both in Europe and America, on new methods and processes for the purification of drinking water, which are being experimented with and adopted for use in various municipalities. A paper by Mr. Ad. Kemna, which appeared in a recent issue of "Engineering News," is of especial interest, reviewing as it does, the most important advances in recent practice in Europe, and more particularly France. Mr. Kemna's article, which is entitled "Novelties in Filtration and Their Theory," follows in part:

"First in importance among the novelties are the gravel strainers called "dégrossisseurs." Mr. Armand Puech, a cloth manufacturer at Mazamet, Department Tarn, in the south of France, had trouble with muddy waters in his factory. To wash a piece of cloth the water is applied in a spray through a pipe with small holes; these holes were blocked by matter in suspension. He tried filtration through sponges, resorted to clinker or cinder, but met with little success. A sand filter was then used, but the available head being only 3.9 ft. the deeper layer of coarse gravel was replaced by a perforated sheet of iron, supporting 4 ins. of small gravel and 16 ins. of sand; this filter clogged rapidly. Therefore the sand was dispensed with. At first the water passed was more or less opalescent, but gradually the effluent grew better. An important advantage of the plant is great yield, a column 100 to 140 ft per 24 hrs., about 15 times more than a sand filter being obtained. Thus the fact was experimentally established that mere gravel straining at comparatively high speed can clarify a muddy water.

"To ensure better clarification, the thickness of gravel was increased from 4 to 10 ins., with the result that the effluent was better but clogging more rapid. It was then thought that "the mesh of the filter should be proportioned to the size of the particles," which led to the idea of using various grades of gravel of diminishing size, with larger surface areas, which means diminishing speed. The results being satisfactory, Mr. Puech hit upon the idea that

his gravel strainers, doing a lot of work, would relieve ordinary sand filters of all that part of their burden, prolong their life and ensure better results. By facilitating the adoption of sand filtration for municipalities, a large field was open. Not being an engineer, he secured the assistance of Mr. Chabal, and the system is now called "Dégrossisseurs Puech-Chabal." It is working in several places near Paris, at Ismalia on the Suez Canal with the Nile water, and recently has been adopted for the city of Magdeburg on the Elbe.

"A typical installation is the one of the Compagnie des Eaux de la Banlieue de Paris, supplying a maximum of 9,250,000 U. S. gals.; it is at Suresnes, on the slope of the Mont Valerien. The water goes through four beds of gravel at successive speeds of approximately 225,000,000, 130,000,000, 75,000,000 and 45,000,000 U. S. gals. per acre per day and through the two sand filters at speeds of approximately 15,000,000 and 2,500,000 respectively. The plant was started by the middle of November, 1905. Ten days later the river was at its worst, in full flood, a thick, yellow liquid; the effluent from the gravel strainers was scarcely opalescent. Bacterial analyses of water from the last sand filters gave generally much less than 100 colonies. These analyses are made by Miquel, who applies his method of counting after 15 days; his figures are several times higher than with the usual gelatine method after three days; they are much lower than the counts obtained from springs, which at Paris continue more or less to be considered as standard. The last filters run for an indefinite period, more than a year, and even then their loss of head is only 8 ins.

"An experiment has been made at Waelhem, the filtering station of the Antwerp Water-Works Co. An ordinary sand filter of .022-acre was supplied by a gravel strainer of .024-acre in three compartments of 0.006, 0.006 and 0.012 acre. At the normal speed the first two compartments pass 80,000,000 U. S. gals. and the third compartment 40,000,000 U. S. gals. per acre per day. Mixed gravel the same in all compartments was used, but the first compartment clogged quickly; the gravel was then screened in three sizes and now the system works satisfactorily, the effluent being only slightly opalescent.

"Beside the removal of suspended matter there is a very large reduction of free ammonia, with variations, however, dependent on speed, and all the compartments have their share of it. Albuminoid ammonia is much less reduced, and the same is true of total organic matter.

"These are the facts. They can be summarized by saying that there is a very marked retention of suspended particles, even of a very small size, and also a chemical action on organic matter, especially a marked reduction of free ammonia.

"The idea of attempting to retain the finest mud by gravel and at high speed appears at first sight to be impossible. The interstices between the stones are enormous in comparison with the size of a particle of clay. But the clarification is a fact and not only particles of clay, but also microbes are arrested, the strainers sometimes taking out 90%. In winding their course through the tortuous channels in the gravel, the suspended particles must come in contact with the surface of the pebbles, and if this happens to be dirty and sticky, they will be arrested. Mr. Puech considers that the efficiency of his strainers lies in the multiplicity of contacts; he claims that the whole thickness of the gravel layer is working, while in a sand filter there is only the surface layer.

"The general idea of contact with sticky surfaces is certainly correct, but has not been pursued very far in detail. When we consider the mechanics of sticking, it is clear that the adhesive force or sticking action, in order to retain a particle, must be greater than the actions which tend to tear away this particle and make it move on. These actions are in reality the inertia of a moving body, determinated by its mass, m, and its velocity, v; so that for the 'dégroississeur' working we must have $S > mv$. It follows that when v increases, m must diminish; the greater the speed, the smaller the size of particles retained; so that in the first compartment, where Mr. Peuch thinks he is straining off the grossest particles, in reality only the smallest are retained. This idea was forcibly brought to the writer's mind by noticing a reduction of opalescence in a badly conducted experiment, when through a mistake in speed of 465,000,000 gals. per acre per day had been given; of course no result was expected, but there was a good reduction, even for microbes. The straining material was a column of coke 16 ft. deep. The retention is a question of a multiplicity of contacts, largely independent of speed.

"This preliminary treatment of the water, relieving the filter of much of its mechanical work, must, of course, greatly prolong its life and save cleaning; against this asset there is

the cleaning of the strainer itself. But the cleaning of an ordinary filter must be done with some care, while the strainer may be handled roughly. It is claimed that for this item the strainers realize a great economy and this seems confirmed by the practice of the several installations. The long run of the filters is especially advantageous in winter time, as there is the possibility of bridging over a spell of frosty weather without cleaning. The greatest saving appears to be in dispensing with settling tanks or decantation reservoirs.

"The Suresnes works for part of the suburbs of Paris, which have already been described for the gravel strainers of the system Puech-Chabal, are also interesting for several other peculiarities. Special attention has been paid to repeated and thorough aeration of the water. The delivery of each filter into the next is over a long cascade in three steps, over which falls a thin film of water; the arrangement is simple and efficient. Whether the result is beneficial, is another question. The idea is to give the oxygen required for the destruction of organic matter, but such a direct action does not exist; there must be an intermediary carrier of the oxygen, and plant life plays this part; it thrives on the carbonic acid of the water. By injecting air it is not only oxygen but also carbonic acid which is given, fostering vegetation. There is on all the gravel strainers at Suresnes an abundant vegetation, as luxuriant on the fourth compartment as on the first, the stock of carbonic acid, which means food, being at each stage replenished by the cascades. With the experimental tank at Waelhem, vegetation was very troublesome, but appeared mainly in the first compartment; it has been completely stopped by covering over the tank to exclude light."

Commenting on the Puech-Chabal system, "Engineering News" says editorially:

"It is certainly fair to ask whether the same results as Mr. Puech gets by his dégrossisseurs could not be obtained at less expense and greater convenience by sedimentation, or in extreme cases by coagulation and sedimentation combined. Without meaning to detract from the interest of Mr. Kemna's discussion nor to rob Messrs. Puech and Chabal of any credit due them, we submit that before adopting the Puech-Chabal preliminary filters, it would be desirable to test them alongside Maignen and other American roughing filters, alongside mechanical filters, sedimentation basins and combined coagulation and sedimentation processes, and then to use the results in framing estimates of comparative first costs and total annual costs."

In connection with the Puech-Chabal system and its usefulness in treating waters which are especially turbid, the following excerpts from a communication to "Municipal Engineering" by Mr. William B. Fuller will doubtless prove of interest:

"Slow sand filters as now designed and operated completely fail to give a clear effluent when the turbidity in the raw water averages above about fifty on the turbidity scale and it has been considered necessary to use coagulants and in general the mechanical type of filters when the turbidity of the raw water averages a higher amount.

"The cost of coagulant for very turbid waters is a very large item, and including with this cost the objections which many communities raise against the use of coagulants, it is desirable that the slow sand filter be improved so as to remove any degree of turbidity as well as of bacteria.

"It has been observed ever since slow sand filters have been scientifically operated that they were able to take care of considerable overloads of muddy water, provided the periods of overload were comparatively short and not too near together. These abnormal quantities of turbidity are stored in the interstices of the sand grains and gradually work downward through the sand layer and ultimately appear in the effluent if the conditions are prolonged.

"Suppose that while this storage is in progress and before any turbidity has worked through to the effluent, filtration is stopped and the sand thoroughly cleaned to the depth the turbidity has penetrated, it can be readily seen that this property of storage can be made use of indefinitely and with a proper adjustment of the effective size of the sand and its depth turbidity of any amount is easily removed by slow sand filtration. Such an apparatus for cleaning sand quickly to any depth has been in use at Yuma, Arizona, for four years and has been recently thoroughly tested by the writer, in a six months' test for the city of New York.

"The Colorado River water at Yuma is at all times very turbid, at times containing 1 part of silt to 50 parts of water, and averaging throughout the year 1 part in 200; that is, a bright pin will disappear from view at one-half to three-quarters of an inch below the surface of the water.

"A mechanical filter company first installed

a plant at Yuma and had to abandon it, being unable to clarify the water with a coagulant, after which a filtration company invented and installed the machine described below, which has successfully clarified the water for about four years, the filter working at the rate of three million gallons per acre per day.

"The washing machine consists of an inverted open box about four feet square and two feet deep, and suitable operating mechanism. The box is sunk under the water of the filter to the sand surface and is held in position and operated from a platform above, which platform is movable on rails supported by the piers of the filter. The box contains a revolving hollow axle and a hollow head, from which hollow teeth project into the sand any desired distance.

"By means of suitable electrically driven mechanism, all under the control of one operator, the box can be raised or lowered and the platform can be moved forward or backward or sideways. By moving the platform the box is caused to slide over the surface of the sand at a speed of about 10 feet per minute, while at the same time the hollow head and teeth are made to revolve slowly, stirring the sand mechanically. Water under a pressure of 10 to 20 pounds per square inch is introduced through the hollow axle, head and teeth, and passes in strong fine streams into the sand through fine holes in the teeth.

"A suction pump connected with the top of the box is made to draw away just a little more water than is supplied through the teeth and thus carries away and discharges to a sewer all the dirt which has been stirred and washed from the sand.

"On account of some water being drawn inward from the filter into the box under its edges through the sand to make up the deficiency between the amount pumped out and that let in through the teeth, none of the dirty water escapes from the box into the filter, but it is all carried away and discharged through a flexible hose into the sewer.

"The box is slowly moved ahead over the sand and thus every part of the sand surface is gone over and cleaned, after which the machine is lifted from the filter and filtration started. All of the operations of the machine are at all times easily under the control of one operator by simply throwing electrical switches.

"This machine was perfectly successful under the New York experiments and has been recommended for adoption when the proposed Croton filters are constructed. By its use and the intelligent proportioning of the effective size of sand, depth of sand, rate of filtration of water, depth of the sand washed at each cleaning and rate of travel of the machine during washing, any practical degree of both turbidity and bacteria removal is possible, without the use of any coagulant.

"The saving of all cost for coagulant and the small cost of operation of the cleaning machine make the maintenance cost of this new method very much less than that of any other and bring the total capitalized cost of an investment for filters much less than for either regular slow sand or mechanical filters, thus bringing filtration within the reach of many communities now holding back on account of cost."

"Mr. Kemna also describes in his article other new departures in the purification of water which are being tried out at Paris, as follows:

"In most filter beds the sand is supported on a bed of gravel at least 1 ft. thick, and in several layers; the coarsest below, the finest above. In the filters of the city of Paris proper these layers of gravel are now replaced by porous concrete slabs 3 ins. thick, made of small gravel with a minimum quantity of cement. There is a reduction in height of at least 10 ins., a great advantage in installations which cannot dispose of much fall, and also an economy in construction. The porosity is quite remarkable; the water poured on goes through so rapidly that it is difficult to wet the whole surface of the slab. Two objections have been raised: will not the mass get clogged? will not the mass collapse by dissolution of the cement? The two cases are possible. Muddy water will soon put an end to the porosity, but the system is not intended for such waters. Besides this mechanical action from suspended particles, there is the possibility of a chemical precipitate with hard waters, and the reverse with very soft and acid waters, the taking up of the lime of the cement. In the former case the porous slabs would be transformed into solid stone; in the second it would revert to its original state of a heap of loose pebbles. Most likely such events will be quite exceptional and each case for a water supply must be examined on its own merits. At Paris the system has given complete satisfaction for several years.

"Of special interest at present is the St. Maur filtering station of the city of Paris, on account of an experimental competition for

sterilizing the filtered water. Three systems are at work: Treatment with ozone, by Count de Fries (a Dutch nobleman); another by the Otto process; and the Duyk ferrochlore system, the combined action of chloride of lime and chloride of iron.

"It is possible that an ozonizing plant of some magnitude will be erected for some of the springs now supplying Paris with water. The effect of ozonization upon the microbes is a well established fact, so little that is new will be learned; but it will be interesting as to cost, the main point on which there is still grave doubt in the minds of many engineers."

A description of the Otto process, which will be of interest in this connection, recently appeared in "Electrical Engineering," from whose account of the apparatus the following has been abstracted:

The apparatus consists of a small transformer and ozonizer enclosed in a case. A special tap and emulser, in which the ozone is mixed with the water, are also provided. If the supply is from continuous current mains, a small rotary converter must be used to convert it to alternating current. Briefly, the ozonizer consists of a number of glass plates, opposed to each other in pairs. The opposing sides are coated with tin foil, the distance between the coatings being about one twenty-fifth of an inch. Current is supplied to the plates from the transformer at about 15,000 volts. Air is admitted at the top of the ozonizer and is drawn down between the plates between the coatings of which a continuous brush discharge takes place, a large part of the oxygen of this air being converted into ozone. The ozone thus formed is drawn off and mixed with water in the emulser. The apparatus requires very little more power than that required by the no-load losses of the transformer and the consumption of energy is therefore very low. The apparatus is only used when water is to be drawn. When the water is first drawn it smells very strongly of ozone, but in a few seconds the ozone passes off, leaving the water fresh and pure.

Bacteriological analyses of samples of water treated in this manner have shown very satisfactory results, and several municipalities in France are adopting this method and are putting down large and complete installations to deal with the whole town supply. This is being done in the city of Nice, which has a population of about 100,000.

THE ECONOMICAL PRODUCTION OF PORTLAND CEMENT BY THE USE OF HIGH MAGNESIAN LIMESTONE*

By F. B. PECK

CONDENSED FROM "ECONOMIC GEOLOGY."

One of the principal drawbacks in the manufacture of cement, particularly in the Lehigh district, where approximately 50% of the Portland cement of the country is made, is the lack of abundance of a non-magnesian, pure limestone. In most cases the cement rock is too low in lime and the deficiency must be made good by the addition of a limestone containing as small a percentage of impurities as possible. No limestone can be used that runs over 4 or 4½% magnesium carbonate, for the presence of too much (more than 3%) of magnesia in Portland cement reduces the tensile strength and causes the cement to expand and crack after setting.

Recognizing the great desirability in using a limestone high in magnesia, in the manufacture of Portland cement, Mr. Richard K. Meade, chemist for the Dexter Portland Cement Co., at Nazareth, Pa., has recently taken out a patent for a process for making a cement superior in strength to the best grades of Portland cement, out of limestones containing preferably from 5 to 20% of magnesia. The principle which lies at the base of his discovery consists in the conversion, through the addition of calcium chloride or some other chloride, of the magnesia into the oxychloride of magnesia, which

*Condensed from an article entitled "The Cement Belt of Pennsylvania."

is a compound closely related to the oxychloride of zinc, a compound much used by dentists as a cement for filling teeth.

The oxychloride of magnesia has cementing properties greatly superior to those of the best grades of Portland cement, and would consequently add materially to its strength in direct proportion to the amount present. The process (quoting from the patent, No. 866,376, dated Sept. 17, 1907), "consists in mixing with cement rock, sufficient high magnesian limestone to bring the lime and magnesia in the mixture up to the proper ratio to the silica, iron oxide and alumina, the preferred ratio of the calcareous material to the argillaceous material being approximately 2 to 1. The mixture is then ground to an impalpable powder, burned to the point of incipient vitrifaction and a small percentage, preferably from 1 to 10% by weight of calcium chloride is added to the clinker and the mixture ground to the requisite fineness. The proportion of calcium chloride to the mixture will depend upon the percentage of magnesia in said mixture, satisfactory results being obtained by the addition of 2% of calcium chloride to a cement mixture containing 8% of magnesia. Where the cement mixture contains a larger percentage of magnesia a proportionally larger amount of the chloride will be required.

"In place of calcium chloride I may employ other chlorides, preferably metal chlorides, such for example as sodium, or other alkaline chlorides, magnesium, or other chlorides of metals of the magnesium group, barium, or other alkaline earth chlorides; the various chlorides being equivalents of the calcium chloride mentioned, in the practice of my process.

"The calcium or other chloride employed may be added to the materials used in the manufacture of cement before grinding, or before burning, or it may be added to the clinker at any time during the process of grinding, or it may be added to the cement before being used, or to the water or other material mixed with the cement; it being sufficient that the chloride be incorporated with the high magnesian limestone cement at any time prior to the crystallization or setting of the latter in use, and any such incorporation is deemed to be within the spirit of my invention, and the scope of the protection for which I have made application.

"Gypsum or plaster of paris may be added to the materials employed in producing the cement at any time either before or after grinding if found necessary in order to regulate the set. The calcium chloride, or its equivalent, however, serves this purpose, so that the addition of gypsum or plaster of paris is in most cases wholly unnecessary.

"In use, the calcium or other chloride employed combines with the free magnesium oxide in the cement when the latter is mixed with water, and not only renders the latter innocuous, but also forms with it an oxychloride compound having itself great cementing properties. The resulting mixture of Portland cement and oxychloride cement has greater strength and binding properties than the Portland cement itself. It will thus be seen that in the practice of my invention I am not only able to utilize high magnesian limestone in the manufacture of cement, thereby cheapening the cost of such manufacture, but I am also enabled to produce by such use a superior quality of cement."

Mr. Meade's discovery has not yet been put to commercial use. The significance of the discovery will, however, be at once apparent. The search of the cement manufacturers—particularly of those in the Lehigh region—for a high-grade limestone would be ended. Further, instead of using gypsum to retard the set of the cement, they could import calcium chloride with less expense.

In addition to this advantage the cement made by Mr. Meade's process is said to be stronger than ordinary cement. Mr. Meade states that sand briquettes (1 part cement to 3 parts sand), made of cement manufactured according to his process, at the end of seven days stood a test of 300 lbs., while the best grades of Portland are not expected to reach over 250 lbs. At the end of six months they stood a test of 450 lbs., thus showing no retrogression. The cement from which these briquettes were made contained a little more than 8% of magnesia.

THE FLOW OF COMPRESSED AIR IN PIPES*

By E. J. LASCHINGER, M. E.

The subject of compressed air power is one of great importance to the mining industry. The average compressed power installed on a producing mine is about equal to the mill engine power. Efficiency in air power generation, transmission, and application is, therefore, intimately bound up with that problem of perennial interest—reduction of working costs.

The transmission of air power, to a large extent, forms the subject of this paper. The author has no hesitation in expressing the opinion that this phase of the question has not generally received the attention it deserves. The attention bestowed by electrical engineers on the design and construction of their transmission lines is well known, but the same care is seldom given to the installation of air pipe lines. The subject of efficient transmission of air in pipes as affecting our mines suffers from two disabilities—one general and the other local.

The laws of the flow of air in pipes are not generally understood, and various conflicting formulas and tables have been published, none of which, as far as the author is aware, treats the subject thoroughly, or gives data and information in a concise and handy form for use. These formulas mostly introduce unusual factors, and express results in terms which are not convenient. It must, further, be remembered that reliable experiments on the flow of air are few, and therefore the data on which to base a formula are meager. This is the general disability.

As a basis for investigation, the author takes the well-known formula for the flow of water in pipes—

$$H = Z\,(L / D)(v^2 / 2g) \quad \ldots\ldots\ldots\ldots (1)$$

where H is the resistance head in feet height of the fluid.

D is diameter of pipe in feet.

L is length of pipe in feet.

v is velocity in feet per second.

g is acceleration of gravity.

Z is co-efficient of friction.

With the other factors all known, the above equation is solved for the velocity of flow.

In the case of air flowing in a pipe, since the pressure must drop as the air moves from one end of the pipe to the other, and since air is compressible, and because in uniform flow the weight of air per second passing all points is the same, it follows that the actual velocity must be continually increasing. For this reason we will take v to represent the mean velocity of flow at the mean density of the air in the pipe.

The quantity of air (cu. ft. per sec.) is obtained by multiplying the velocity by the area of the pipe in square feet.

Multiplying next the quantity in cubic feet second by the density of the air (lbs. per cu. ft.), we obtain as a result the lbs. per second weight of air flowing.

All calculations on the compression of air and work done by air engines are usually and most conveniently carried out on the weight of air basis, and it will be found most advantageous to use this basis also for transmission calculations.

Nearly all the formulas and tables published heretofore have given the flow of air either in cubic feet at terminal pressure or as free air at atmospheric pressure (14.7 lbs. sq. in. and 60° F.). At this altitude the usual free air basis does not hold good, but the weight of air basis holds good at all pressures, altitudes and temperatures. Calculations on steam are always carried out on the weight bases, and engineers are familiar with this, and it only requires a little experience and practical acquaintance with the working out of air problems to convince anyone of the simplicity and convience of using the same notation when dealing with air.

Assuming a uniform average temperature throughout, introducing all the above factors, and converting into the usual units of measurement, we obtain the following equation:

To find flow—

$$W = \sqrt{(\pi^2 g / 192\ R)} \times \sqrt{[d^5 / (p_1^2 - p_2^2) / Z\ L\ T]} \ldots (2)$$
$$= 0.17625\ \sqrt{[d^5\ (p_1^2 - p_2^2)\ /\ Z\ L\ T]}.$$

also to determine diameter, mean velocity of flow and terminal pressure:

$$d = 2.0024\ \sqrt[5]{[W^2\ Z\ L\ T / (p_1^2 - p_2^2)]} \quad \ldots\ldots (3)$$

$$v = 23.886 \sqrt{[d\ T\ (p_1 - p_2) / Z\ L\ (p_1 + p_2)]} \ldots (4)$$

$$p_2 = \sqrt{(p_1^2 - 32.9\ W^2\ Z\ L\ T / d^5)} \quad \ldots\ldots\ldots (5)$$

*Condensed from a paper read before the Transvaal Institute of Mechanical Engineers.

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When W = lbs. air delivered per second.
d = diameter of pipe in inches.
p_1 = initial pressure lbs. per sq. in. absolute.
p_2 = final pressure lbs. per sq. in. absolute.
T = absolute temperature (460.7 + °F.).
L = length of pipe in feet.
R = A constant for air = 53.22.
π = 3.14159.

It may be worth while to mention that in the above formulas $p_1 - p_2$ represents the drop or loss in pressure.

$p_1 + p_2$ represents twice the average pressure, and since

$$p_1^2 - p_2^2 = (p_1 - p_2)(p_1 + p_2)$$

the expression $(p_1^2 - p_2^2)$ is equal to twice the product of the drop in pressure in the mean pressure.

It remains now for the practical application of the above formulas to determine the probable value of Z, the coefficient of friction. This can only be done by analyzing the results of actual experiments on the flow of air. It has been found that Z is not a constant quantity, but varies with the diameter, becoming less as the diameter increases and probably also as the velocity increases, as has been proven in the case of the flow of water. Tests on the flow of air are difficult to carry out, involve many sources of error, and are also expensive to conduct. These reasons, together with the fact of the lack of the usual facilities for carrying out such experiments, are no doubt responsible for the meager materials available for fixing the value of the coefficient of friction.

There are, however, the experiments of Stockalper at the St. Gotthard Tunnel, and of Gutermuth-Riedler on the Popp air-power system of Paris; also experiments by Devillez and Lorenz, which the author has compared with the data on the Stockalper experiments given in Kent's pocket-book, and the Gutermuth-Riedler experiments in Professor Unwin's book "On the Development and Transmission of Power."

From all these results the author deduces a formula for the value of the coefficient of friction Z, which would give its probable value for various diameters.

$$Z = 0.005 + 0.03/\sqrt{d} \quad \ldots\ldots\ldots\ldots (6)$$

where d is the diameter of pipe in inches. (See Table I.)

The formulas on flow as given look somewhat formidable, and for practical purposes and everyday use further simplication may be adopted. For mining work on the Rand we may assume 80° F. as an average underground temperature. Taking a unit length of 1,000 ft., and working on the average pressure of the compressed air in the pipe at a drop in pressure of 1 lb. per square inch, and converting into lbs. of air per minute, we obtain the following formula:

TABLE I.—Coefficients of Friction (Z) for Air Flowing in Pipes, and Factors (C) for Finding Flow.

Nominal Diam., ins.	Actual Diam., ins.	Coeff. Z.	Equivalent length L_1*	Factor C.
1	1.05	.03428	2.6	.10871
1 ½	1.61	.02864	4.7	.32631
2	2.07	.02585	6.7	.71064
3	3.07	.02212	11.6	2.1221
4	4.03	.01994	16.8	4.6020
6	6.07	.01718	29.4	13.655
8	7.98	.01562	42.6	29.467
10	10.02	.01448	58	53.429
12	12	.01366	73	86.803
16	16	.01250	107	186.27
20	20	.01171	142	336.20
24	24	.01112	180	544.23

*L_1 = length in feet of pipe whose frictional resistance is equivalent to the velocity head.

Flow of air lbs. per min. = $W_1 = C\sqrt{p.h.}$ (8)

Where c is a constant for each size of pipe.

p is the mean pressure in the pipe, lbs. square inch.

h is the drop pressure, lbs. square inch.

The values of C are given in Table 1.

The quantity of air flowing in a pipe varies inversely as the square root of the length—i. e., a pipe of four times the length would give half the flow, and a pipe of quarter the length would give double the flow. To find the flow for any particular pipe the simple procedure would be to obtain from the tables the flow, assuming the pipe to be 1,000 ft. long, and then multiply that result by $\sqrt{(1{,}100/L)}$.

Since quantity of air is commonly expressed in cubic feet of free air per minute, this can be conveniently found from the results of our formulas and tables by multiplying by the specific volume of air.

At sea level (14.7 lbs. per sq. in.) and 60° F.—13.091 cu. ft. per lb. air.

At Johannesburg level (12.1 lbs. per sq. in.) and 60° F.—15.904 cu. ft. per lb. air.

At Johannesburg level (12.1 lbs. per sq. in.) and 80° F.—16.515 cu. ft. per lb. air.

So far we have been considering the flow of air in horizontal pipes. It stands to reason that if compressed air be delivered in a pipe with its discharge end at a different elevation to the inlet, the condition of flow will be somewhat modified. The mean density of the air will be different, and therefore the flow will be affected. Taking the case of a pipe delivering air down a vertical shaft, it is evident that the weight of the air assists the flow, and this is manifested by an increased pressure at the bottom. If the friction loss be less than the increase of pressure due to depth, then the pressure at the bottom will be greater than at the top; if the friction loss be greater than the increase of pressure due to depth, then the bottom pressure will be less than the top pressure.

Now, in the construction of our formula we assumed that the flow varied directly as the mean density, and the mean density varied as the mean pressure. For the mean pressure we assumed the average of the end pressures. This assumption is not absolutely and theoretically correct, but without such an assumption the formula would be so complicated as to be almost impossible of practical application, and, considering the sources of uncertainty in our experimental coefficient, no more reliable in its results. This being the case, it is quite safe to assume that the influence on flow due to depth is allowed for by calculating the static pressure at the bottom of the pipe, deducting the resistance loss, and taking the mean pressure as the average of top and bottom pressures.

Now, the ratio of bottom to top pressure varies as the Naperian logarithm of vertical depth.

We have

$$\log_e = Pb/Pt = L_1/RT \quad \ldots\ldots\ldots (9)$$

or Pb/Pt = 2.3026 times common log of L_1/RT.

Where L_1 is vertical depth in feet.

R is constant for air = 53.22.

T is absolute temperature, Fahrenheit scale.

To obtain the flow of air in a pipe down an incline or vertical shaft, it would be necessary to multiply the top pressure by the ratio of pressures corresponding to the vertical depth to find the bottom static pressure; then deduct from this the frictional loss to get the true bottom pressure. The average of the top and bottom pressure now gives the mean pressure to use in the calculations.

This proceeding may be an unnecessary refinement for most practical purposes, yet the influence of depth is very marked in its effect at great depths—at 3,000 ft. it represents an increase of 11% in pressure. We come now to a very important matter affecting the flow of air in a piping installation in practice, and that is, the resistances due to receivers, valves, bends, etc. These have a marked effect on the flow and on the resultant final pressure.

Unfortunately, experiments to determine these losses for air and gases are practically non-existent, yet even approximate determinations will be better than neglect of these factors or pure guess work. Fortunately, coefficients for various resistances have been experimentally determined for the flow of water, and nearly all investigators are agreed as to the form of expression representing these losses.

One way of dealing with these resistances is to allow a certain drop of pressure; but how much should be allowed? The objection to this loose method of treatment is obvious. Again, the question arises: Since flow depends on the mean pressure, should the loss of pressure due to bends, etc., be deducted before making calculations on flow or after? It is also generally agreed that these losses of pressure vary directly as the square of the velocity of flow, and will, therefore, vary with the amount of air passing through the pipe.

There is, however, a satisfactory way out of these difficulties, and that is to express these resistances in terms of equivalent lengths of pipe. As before indicated, it is generally assumed by authorities on pneumatics and hydrodynamics that the resistances are best expressed in terms of the velocity head, and therefore we will so use them in our formula.

We commenced our investigations with the fundamental equation (1) where H is the resistance head and $v^2/2g$ is the velocity head.

If we, therefore, put for our unit of resistance the equivalent of the velocity head, the term Z (L/D) = 1, the length of pipe which would lose in friction the energy of the velocity head would, therefore, be

$$L = d/12\,Z \quad \ldots\ldots\ldots\ldots\ldots (10)$$

where d is diameter in inches.

In Table I, the fourth column gives values of length of pipe in feet, giving our unit resistance, equivalent to the velocity head.

Certain authorities on the flow of air and steam in pipes express resistances as above but assume that these resistances are equivalent to a length expressed in diameters of pipe. A constant coefficient of friction for all diame-

ters of pipes has evidently been taken for granted, but this is not true, and, therefore, the results must be wrong also.

In putting forward probable values for the coefficient of resistance for various pipe fittings, etc., the author does so without full confidence, because of a lack of experimental data necessary to arrive at reliable results; still, there is some material available on which to build, so for want of fuller information the results may be accepted with some degree of approximation to the truth.

ENTRANCE HEAD.

The initial velocity has to be given at the expense of pressure energy equivalent to the velocity head. This loss is, therefore, in our measure, unity. There is a further loss due to the edges of a pipe causing contraction of the flow. In the case of water, with sharp edges of the orifice, this is equal to about four-tenths of the velocity head. With well-rounded edges or a conical mouthpiece this loss is almost negligible. Let us take the total factor at 1.5 times the velocity head.

AIR RECEIVER OR SUDDEN ENLARGEMENT.

When a fluid at a high velocity debouches into an enlargement, its velocity head is destroyed, and in again entering the outlet pipe the energy of entrance head is again required. If the change of cross-section be effected gradually with diverging and converging tubes, there is practically no loss. This refinement of design is, however, so seldom met with in practice that we can afford to neglect it.

The loss in a receiver would, therefore, be on the above theoretical consideration equivalent to about 2.5 times the velocity head.

The Gutermuth-Riedler experiments, however, included some separate investigations on the losses in large receivers. The loss of pressure in these tanks was very considerable, the coefficient of resistance being about twenty times the amount which would be given by the method of calculation based on our theoretical investigation.

Unwin calculates a factor of resistance due to these tanks in the form

$$p_r = f\ p\ v^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (11)$$

where p_r = loss of pressure lbs. per sq. in.

p = absolute pressure of air lbs. per sq. in.

v = velocity in feet per second.

f = factor of resistance.

If we represent the coefficient of resistance adopted in this paper by "k," the ratio of the two factors will be

$$k = 2g\ RT\ f. \quad \ldots\ldots\ldots\ldots (12)$$

Where g is the acceleration of gravity.

R is constant for air—53.22.

T is absolute temperature.

Taking the average value of k as found (= 45.3) we deduce that the resistance effect of a receiver is—

In an 8-in. pipe equivalent to 1,930 ft. of pipe.
In a 10-in. pipe equivalent to 2,630 ft. of pipe.
In a 12-in. pipe equivalent to 3,310 ft. of pipe.

These results appeared to the author so inexplicable that he determined to avail himself of the earliest opportunity of finding out from actual experiment what the losses in a plain receiver (of the type common on the Rand) would be.

A few experiments were, therefore, conducted at the Robinson Deep G. M. Co. on the night of December 3-4, 1907.

The estimated resistances for the above receiver, according to the author's data as given in the paper, would be:

Entrance to Receiver.		
Resistance of Tee.....	k =	2.0
Resistance of gate valve.....	k =	0.2
Loss of velocity head.....	k =	1.0
Total.....		3.2

Observed average, 3.41.

Exit from Receiver.		
Entrance to Pipe.....	k =	1.5
2 elbows r/d = 0.8 @ .48.....	k =	0.96
8 ft. of 7-in. Pipe 8/135.8.....	=	0.22
		2.68

Observed average, 2.32.

These results agree so closely that they inspire some measure of confidence in the co-efficients given in Tables II. and III., and in the method of treatment of resistance due to pipe fittings as adopted in this paper.

The above results are fairly concordant considering the difficulty of reading small differences of pressure where the mercury in the manometer responds to the pulsations of the air as delivered by the compressors.

It seems evident from the above that the resistance measured by Riedler included more than the losses due to a simple receiver.

TEES.

As most tees and crosses have fairly sharp corners, the resistance may generally be taken as equivalent to an elbow of radius very slightly larger than the diameter of the pipe.

BENDS.

The researches of Weisbach on the effect of bends give the following results:

TABLE II.—Flow of Air in Pipes.—Resistance of Various Fittings.*

(Unit of Resistance = Velocity Head.)

Nature of Resistance.	Coefficient of Resistance.
Receiver	2.5
Entrance head	1.5
Sharp elbow	2.0
Round elbow	1.0
Easy bend	0.2
Tee or cross	2.0
Globe valve	4.0
Angle valve	2.5
Gate valve	0.2
Cock	0.5

*To obtain length of pipe giving resistance equivalent of fitting as above, multiply factor corresponding as above by equivalent length—Col. 4, Table I.

E. G.: Sharp elbow, 8-in. pipe—2.0 × 42.6 = 85.2 ft. is equivalent resistance length.

TABLE III.—Resistance of 90° Bends in Terms of Velocity Head.

r/d.	Resistance, coefficient.	r/d.	Resistance, coefficient.
5	0.13	1.1	.26
4	0.135	1.0	.29
3	.14	.9	.36
2	.15	.8	.48
1.5	.17	.7	.68
1.4	.18	.6	1.08
1.3	.19	.55	1.41
1.2	.22	.5	1.98

(r = radius of bend; d = diameter of pipe.)

VALVES AND COCKS.

These are generally of such varying types that it is most difficult to give a value to their probable resistance.

A globe valve full open has about the resistance of two sharp bends.

The resistance of a gate value and cock full open are theoretically nil, but the gate valve certainly must interfere with the flow to some extent, and in a cock there is generally considerable contraction of area and rough and sharp edges.

The coefficients of resistance as given in Table II. will probably give a loss of pressure somewhat in excess of the actual, but in designing a system of air power lines, especially for a rock drill or underground installation, it is best to be on the safe side, so that when the work comes into operation the actual underground pressures may be a little more favorable than the calculated results. Leakage losses must always occur to some extent, and it is impossible to construct a rational formula to allow for leakages and carelessness. For the above reason also the author has taken the mean temperature at a somewhat high figure, because this would also tend to give conservative results.

The resistance due to bends, etc., should never be entirely neglected in making a calculation, because it often may happen that these resistances are greater than that of the piping itself. Our treatment of the subject of these resistances may be open to objections, yet for want of further data it seems the best way of dealing with the problem. The author wishes to emphasize the above points.

In order to make use of the formulas and tables in their application to rock-drill work, it is, of course, necessary to know what is the consumption of air by rock drills. The most convenient unit to use is again the lbs. weight of air per minute. The unit usually employed is cubic feet of free air per minute, but the conversion to the weight basis is simple.

TABLE IV.—Air Requirements for a Rock Drill System.

(One 3¼-in. drill requires 7 lbs. of air per minute average. For any other number of drills, multiply No. of drills by 7 and then by factor below to obtain average lbs. of air required per minute.)

No. of Drills.	Factor of Running Time.
1 — 3	1.00
3 — 5	.95
5 — 10	.92
10 — 15	.90
15 — 30	.85
30 — 100	.80
Over 100	.75

From data which the author has at his disposal, it may be assumed that a fair average for the air consumption of a modern 3¼-in. drill (the usual size met with on the Rand) would be about 7 lbs. per minute of actual running time. If the air consumption runs much above that it would be well to look for a fault in the drill.

We must now consider the question of the effect of having a number of drills operating together and the effect of this on the average consumption of air per drill.

After looking through such data as are avail-

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able, and taking into consideration the factor of running time, the author suggests the basis of the Table IV., for estimating the probable air requirements.

In connection with rock drills, it is worth while to give passing attention to the amount of air used by sprays for laying the dust.

For a sprayer having the air orifice 1-16th inch diameter, the air used would be about ¼ lb. per min. at 50 lbs. pressure.

It is thus seen that, although the amount of air used is appreciable, still it is not large, and would increase the average air consumption per drill by, say, about 4%. Since, however, the running time of the spray would be only about one-quarter of the time of the drilling operations, the amount of air used by the spray would represent about 1% increase in the air requirements per drill.

To obtain the air consumption of underground pumps, winches, etc., probably the simplest method is to take the piston displacement in cubic feet per minute at average speed, and multiply this by the density at the initial absolute pressure of the air entering the cylinder. This would give the pounds of air per minute required by pumps, etc., without cut-off, as, for instance, in direct-acting pumps, in which the air does displacement work only without expansion. In the case of winches, rotative pumps, etc., working on a cut-off, the air consumption would be obtained by multiplying the result arrived at above by a fraction representing the average cut-off.

The density of air is given by the formula—

$$w = P/RT = 144\ p/[53.22\ (460.7 + t)] \quad (13)$$

Where t is the temperature in degrees F. and p is the absolute pressure in lbs. per sq. in.

Another method of treating the subject is the following: Where air is not used expansively, there is developed in the air cylinder by each lb. of air per minute

$$0.872\ (p_a/p_g)\ HP \quad (14)$$

or for each indicated HP. in the air cylinder there are required

$$1.15\ (p_a/p_g)\ \text{lbs. of air per minute} \quad (15)$$

where p_a is the absolute pressure in lbs. per sq. in.

were p_g is the gage pressure in lbs. per sq. in.

These formulas may be applied for finding the probable air consumption of small pumps, etc. If the air be used expansively there will be less air used per horse-power.

For ordinary practice we may take the figures of ¾-HP. per lb. air, or 4/3 lbs. air per I. HP., and then make allowance for friction and losses by doubling the figures for small pumps and winches, to get the amount of air per useful horse-power in work done.

It is not proposed to go into the question of large underground aid winders and rotative pumps, as such cases would merit full treatment in a separate paper.

Having now given the data and explanations on which to base calculations on air pipes, there is one point to which attention should be called.

After a series of calculations has been made and the sizes, etc., satisfactorily determined, the velocity of the air should be calculated for any permanent and important pipes. This velocity should not be too high—not to exceed, say, 50 ft. per second.

For our purposes we need not consider the transmission of air for very long distances, but we should put our initial maximum velocity at or under 50 ft. per second.

Translating Unwin's formula for the relation of initial velocity to terminal pressure into the units used in this paper, we have the following:

$$u = \sqrt{[(g\ R\ T\ d/12\ Z\ L) \times (p_1^2 - p_2^2)/p_1^2]} \quad (16)$$

The initial velocity is, of course, also given by the formula—

$$u = V\ p_m/p_1 = V\ (p_1 + p_2)/2p_1 \quad (17)$$

Where p_m is mean pressure.

If the mean velocity of flow in a pipe system which is being designed fall out high, it would be advisable to work out the initial velocity by either of the above formulas, and if the result be higher than 50 ft. per second, to make the pipes larger.

The necessity of keeping down the velocity of flow so that it may not be excessive may be expressed conveniently in the rough rule below, applicable in the design of pipe systems for initial pressures of 80—50 lbs. per sq. in. gage.

For pipes of various diameters the loss of pressure per 1,000 ft. length should not exceed the values given below:

Size of pipe.	Loss of pressure.
18 ins. — 14 ins.	1 lb. sq. in.
12 " — 10 "	1½ " " "
9 "	2 " " "
8 "	2½ " " "
7 " — 6 ins.	3 " " "
5 "	4 " " "
4½ "	5 " " "
4 "	6 " " "
3½ "	7 " " "
3 "	8 " " "
2½ " — 2 ins.	10 " " "
Smaller	15 " " "

The theoretical horse-power lost in friction of air in pipes is

$$HP. = 0.872\ W\ (p/p_m) \ldots\ldots\ldots (18)$$

where p_r is the pressure (lbs. per sq. in.) loss.

p_m is absolute mean pressure of air in pipe.

W_1 is lbs. air per minute.

It will thus be seen that the power lost for a certain loss of pressure increases rapidly as the absolute mean pressure of the air decreases; the higher the pressure, the less the loss. This point was proven in practice on the Popp air power system. For economical transmission of air power high pressures should, therefore, be maintained. Air power transmission is thus analogous to electric power transmission.

BIBLIOGRAPHY OF BOOKS AND ARTICLES

ON HEATING, LIGHTING, AND POWER DEVELOPMENT BY MEANS OF

DENATURED ALCOHOL

Compiled by S. M. WOODWARD*

In this bibliography only those references are given which it thought may be of value to investigators. The list given might be greatly extended by referring to less important articles. Heating and lighting apparatus have been included with alcohol engines because in most foreign expositions and publications they have been treated together. Most of the references have been personally examined, but some are included which have been obtained from engineering indexes and from other sources. Lack of time available for its composition has prevented the list from being complete, but it is hoped that about all of the more valuable sources of information have been included.

Arachequesne, G.

Lighting and Heating Apparatus at the Paris International Competition of 1902 of Motors and Apparatus Using Denatured Alcohol. (Concours International de Moteurs et Appareils Utilisant l'Alcool Dénaturé. 1. Appareils d'Eclairage et de Chauffage). Mémoires de la Société des Ingénieurs Civils de France, Paris, Année 1902, 2. Vol., No. 8, Aug., 1902, pp. 159-181, 16 figs. 7000 w.

A description of the devices exhibited for utilizing alcohol in incandescent burners and in heating appliances. An abstract of this paper was printed in the Journal of Gas Lighting, London, Vol. 81, No. 2070, Jan. 13, 1903, pp. 102-104, 4 figs., 2,000 w.

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Chaveau.

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Chauveau, G.

A Contribution to the Theory of Alcohol Engines. (Une Contribution à la Théorie du Moteur à Alcool.) Compte Rendus de Congrès des Applications de l'Alcool Dénaturé, Paris, 1902, pp. 219-230, 3 tables, 4000 w.

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Coupan, G.

The Vienna International Alcohol Exposition. (L'Exposition Internationale des Al-

*Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.

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Coupan, G.

Competition and Exhibition of Alcohol Motors and Apparatus: Motors, Automobiles and Boats. (Concours et Exposition de Moteurs et Appareils Utilisant l'Alcool Dénaturé: Moteurs, Automobiles et Bateaux.) Le Génie Civil, Paris, Tome 41, No. 8, June 21, 1902, pp. 117-123, 5 tables, 2 half-tone general views. 5000 w.

Description of the motors, automobiles, and boats using alcohol in the competition held at Paris, May, 1902. A detailed account of the methods of conducting the tests and the tabulated results.

Coupan, G.

Exposition of Motors and Apparatus for Using Denatured Alcohol. (Concours et Exposition de Moteurs et Appareils Utilisant l'Alcool Dénaturé.) Le Génie Civil, Paris, Tome 40, No. 5, Nov. 30, 1901, pp. 69-73, 4 half-tone general views, 3 tables, 2500 w.

An account of the history, organization and execution of the tests of stationary motors and automobiles at the Paris competition of November, 1901. The best results obtained by the prize winners are given.

Covert, John C.

The Paris Exhibition of Alcohol-Consuming Apparatus. U. S. Consular Reports, Advance Sheets, No. 1161, Oct. 14, 1901, 4 pages, 1000 w.

Announces the exhibition in Paris of inventions for the use of alcohol for illuminating and heating purposes, and gives notes from a French government report upon this subject.

Cree, Joseph C.

Exhibition of Alcohol Appliances at Lima. [Feb. 28-Mar. 31, 1903.] U. S. Monthly Consular Reports, Washington. Vol. 72, No. 274, July, 1903, pp. 341-343, 600 w.

A brief description of the exhibits at the Lima Exposition, opened Feb. 28, 1903.

D. F.

The Use of Alcohol in Motors for Automobiles. (L'Emploi de l'Alcool dans les Moteurs d'Automobiles.) Le Génie Civil, Paris, Tome 39, No. 9, June 29, 1901, pp. 140-143, 6 tables, 2500 w.

A tabulated review of the performance of 30 different kinds of vehicles using alcohol in internal combustion motors. A description of the road trials with alcohol held in France up to that time, including a single test over 136 kilometers in 1899, a summary of the results of the trial October 28, 1900, Paris and Rouen, in which 39 vehicles finished the course of 127 kilometers and the contest of April 7 and 8, 1901, Paris and Roubaix, 270 kilometers, in which 46 contestants completed the trial. All the results of the latter contest are given in tabular form.

Dawson, Charles E.

The Alcohol Motor. The Gas Engine, Cincinnati, Vol. 8, No. 8, Aug., 1906, pp. 236-237, 1000 w.

Gives the density, boiling point and latent heat of vaporization of different proportions of alcohol and water and discusses the best compression to be used in alcohol motors.

Denayrouze, Louis.

Progress in Alcohol Lighting. (Progrès Réalisés dans les Applications Industrielles de l'Alcool Eclairage.) Mémoires de la Société des Ingénieurs Civils de France. Paris, Année, 1902, 2. Vol., No. 12, Dec. 1901, pp. 971-975, 1500 w.

A review of the great advance made in alcohol lighting in France in the preceding three years. The report is also discussed on pages 877 and 878.

Denayrouze, Louis.

Illumination by Alcohol. (L'Eclairage par l'Alcool.) Mémoires de la Société des Ingénieurs Civils de France, Paris, Année 1899, 1. Vol., No. 6, June, 1899, pp. 1015-1025, 2500 w, with discussion on pp. 930-936.

A paper before the society, describing the construction of carburated alcohol lamps for use in connection with incandescent mantles.

Dhommée, Réné.

Carbureters for Alcohol Motors. (Carburateurs pour Moteurs à Alcool.) La Revue Technique, Paris, Tome 25, No. 15, Aug. 10, 1904, pp. 816-817, 6 figs. 1200 w.

Six different kinds of German alcohol carbureters are illustrated in such manner as to show their interior construction and operation.

Diederichs, H.

Some Notes on Gas Engines. Part V., Alcohol as a Fuel, Sibley Journal of Engineering, Ithaca, N. Y., Vol. 18, No. 8, May, 1904, pp. 340-347; also pp. 53-60 of the reprint of this article, published under the same title with separate pagination. 3000 w.

Discusses use of alcohol engines in Germany; gives cost and efficiency of alcohol compared with other liquid fuels, and their relative advantages and disadvantages.

Diederichs, H.

The Use of Alcohol as a Fuel for Gas Engines. International Marine Engineering, New York, Vol. 11, No. 7, July, 1906; pp. 264-270, 11 figs. 5000 w.

This article treats of the fuel value and physical properties of alcohol, the details of the alcohol engine wherever they differ from the gasoline or crude oil engines, the efficiency and cost of the different liquid fuels and the results of the German tests of alcohol engines.

Reprinted, with slight omissions, in Scientific American Supplement, New York, Vol. 62, No. 1596, Aug. 4, 1906, pp. 25,568-25,571.

Reprinted in abstract in Machinery, New York, Aug., 1906, pp. 644-647.

Dieudonné, Emile.

Alcohol and Gasoline for Automobiles. (L'Alcool, l'Essence de Pétrole et l'Automobilism.) La Revue Technique, Paris, Tome 22, No. 8, April 25, 1901, pp. 172-174. 2500 w.

A discussion of the relative calorific powers of the various liquid fuels with regard to their use in the internal combustion motors of automobiles.

Dupays, Henri.

Mechanical and Commercial Aspects of the Alcohol Motor. Engineering Magazine, New York, Vol. 26, No. 5, Feb. 1904, pp. 682-693, 8 figs, 2800 w.

A description of the alcohol engines tried in France. The article is based chiefly upon Ringelmann's Paris tests.

Fehrmann, Karl.

Alcohol Fuel for Explosion Engines. Mechanical Engineer, London, Vol. 17, No. 440, June 30, 1906, pp. 914-918, 10 figs. 4500 w.

Also in The Horseless Age, New York, Vol. 17, No. 23, June 6, 1906, pages, 872-876, figs. 10.

An abstract translation of a paper read before the German Automobile Technical Association reporting investigations and results showing slight prospects of alcohol supplanting gasoline.

Fehrmann, Karl.

Spirit Motors. (Les Moteurs à Alcool.) Die Spiritus Motoren. Ergänzunge-Heft zum Katalog der Ausstellung für Gärungsgewerbe zu Berlin, May 29-June 7, 1903. Berlin, P. Parey, 1903.

English version pp. 113-120, French version, pp. 57-65 of French-English edition. German version pp. 57-64 of German edition.

Gerdes.

Lighting by Acetylene and Alcohol Incandescent Lamps. (Neueres Ueber Acetylen und Spiritus-Glühlicht Beleuchtung.) Glaser's Annalen für Gewerbe und Bauwesen, Berlin, Bd. 42, No. 496. Feb. 15, 1898, pp. 61-64, 3000 w.

A paper before the Verein Deutscher Maschinen-Ingenieure, comparing the light obtained from acetylene with that from alcohol incandescent lamps, with discussion.

Great Britain.—Treasury:—Industrial Alcohol Committee.

Minutes of Evidence Taken Before the Departmental Committee on Industrial Alcohol, with Appendices. Presented to Both Houses of Parliament. London: Wyman & Sons, 1905, 284 pages.

A complete report of the extensive hearings held by the committee. Most of the evidence taken relates to various chemical industries, and very little of it refers to the consumption of alcohol by burning. Appendices give the fiscal regulations relating to spirits and the regulations concerning the use of industrial alcohol in the United Kingdom, Germany, France, Switzerland, Austro-Hungary, Russia, Holland, United States and Belgium.

Great Britain.—Treasury:—Industrial Alcohol Committee.

Report of the Departmental Committee on Industrial Alcohol. Presented to Both Houses of Parliament. London: Wyman & Sons, 1905, 27 pages.

Gives the conclusions found as to existing conditions and recommendations as to needed changes in the law relating to industrial alcohol. It also contains a very complete report of a sub-committee on the situation in Germany.

Grimshaw, Robert.

Alcohol for Industrial Purposes. Machinery, New York, May, 1903, 3 figs. 2000 w

Describes exhibits at exposition of 1903 of alcohol motors, heating and lighting apparatus. Discusses wide use of such apparatus in Germany and describes and illustrates by three sections the Brillié motor and carbureter. Quotes the tests of E. Meyer on three Marienfeld motors.

Guérin, H.

Lighting and Heating Apparatus at the Exposition of Motors and Appliances for Using Denatured Alcohol. (Concours et Exposition de Moteurs et Appareils Utilisant l'Alcool Dénaturé: Eclairage et Chauffage.) Serial in Le Génie Civil, Paris, Tome 40. First article, No. 6, Dec. 7, 1901, pp. 88-92, 9 figures of lamps, 1 table of calorific powers. 4000 w.

Discusses different methods of denaturing, chemical and physical properties of alcohols and other illuminants, and describes and illustrates, and gives efficiencies of different types of lamps exhibited at Paris alcohol exhibiton of Nov. 1901.

Concluding article, No. 7, Dec. 14, 1901, pp. 104-106, 11 figures of heating apparatus, 2000 w. Describes the various types of alcohol heating apparatus exhibited.

Guérin, H.

The International Competition of Alcohol Motors and Apparatus: Lighting and Heating Apparatus. (Concours International des Moteurs et Appareils Utilisant l'Alcool Dénaturé; Eclairage et Chauffage.) Le Génie Civil, Paris, Tome 41, No. 7, June 14, 1902, pp. 103-106, 10 figs. 2400 w.

An illustrated description of alcohol lamps and heaters exhibited at the Paris exposition of May, 1902.

Güldner, Hugo, and Luedecke.

Alcohol for Running Engines (Spiritus zum Betriebe von Motoren.) Zeitschrift des Vereines der Deutscher Ingenieure, Bd. 46, No. 11, March 15, 1902, pp. 403-404, 700 w.

A discussion of the cost of running engines on alcohol fuel. The fuel consumption results of the French tests of Nov. 1901 are quoted in tabular form.

Also in No. 17, April 26, 1902, pp. 623-624, 2000 w. A discussion of fuel consumption, efficiency and fuel cost of alcohol as compared with other liquid fuels. The discussion is in the form of letters from Güldner and from Luedecke to the editor of the Zeitschrift.

Haenssgen, Oswald H.

The Alcohol Motor. The Gas Engine, Cincinnati, Serial [Part] I, Vol. 4, No. 9, Sept. 1902, pp. 276-278, 1200 w. Part II., No. 10, Oct. 1902, pp.307-310, 1600 w. Part III., No. 11, Nov. 1902, pp. 340-349, 7 figs, 2500 w.

Discusses the economic factors affecting the development of the use of alcohol engines in Europe, considers the differences between alcohol and gasoline engines, describes and compares various types of vaporizers, and gives results of tests of alcohol engines.

The articles are republished, with some alterations, in The Gas Engine, Vol. 8, No 9 Sept., pp. 270-274, and No. 10, Oct., 1903, pp. 302-309.

Krarup, Marius C.

The Status of Alcohol as a Power Source. Iron Age, New York, Vol. 70, No. 2, July 10, 1902, pp. 4-6, 3300 w.

Discusses the trials of alcohol motors in France and Germany.

Krarup, Marius C.

Scientific Tests of Alcohol Motors. Iron Age, New York, Vol. 70, No. 4, July 24, 1902, pp. 4-6, 3300 w.

A discussion of the 1902 tests in France, including the necessity of guarding against corrosion, and treating of the defective combustion of all explosion motors.

Krarup, Marius C.

Carbureted Alcohol versus Pure Gasoline in Automobiles. Iron Age, New York, Vol. 70, No. 9, Aug. 28, 1902, pp. 18-19, 3 tables, 2000 w.

A comparison between results obtained with carbureted alcohol in France, and with gasoline in the United States.

Krarup, Marius C.

Tax-free Alcohol for Industrial Purposes. American Machinist, New York, Vol. 27, No 52, Dec. 29, 1904, pp. 1737-1741, 5000 w.

Summarizes previous articles by the author in the same volume, and discusses the probable development of the use of denatured alcohol in America in view of its fitness for industrial purposes, of the cost of production, and of the political support given to the revision of internal revenue laws.

Krarup, Marius C.

Alcohol for Motors. American Machinist, New York. Serial [Part] I., Vol. 27, No. 41, Oct. 13, 1904, pp. 1362-1364, 2500 w.

This article discusses the causes that led to the use of alcohol in Europe, its merits as a fuel and its importance to engine builders.

Part II., No. 42, Oct. 20, 1904, pp. 1401-1403, 1 table, 3000 w. Gives a list of sources of information in regard to the technical status of alcohol for motor use, different kinds of alcohol used for various purposes in different countries, and their relative calorific values.

Part III., No. 43, Oct. 27, 1904, pp. 1428-1430, 3 tables, 3000 w. Compares alcohol with gasoline as source of motive power from point of view of efficiency and economy, and gives results of tests made with different engines.

Part IV., No. 45, Nov. 10, 1904, pp. 1494-1496, 3 figs., 3500 w. Continues discussion begun in Part III., with comments on progress made in development of engines especially fitted for the use of alcohol.

Leplae.

Results of Tests of Alcohol Motors in Germany. Scientific American Supplement, New York, Vol. 55, No 1425, pp. 22840-22841, April 25, 1903, 2000 w.

A translation from the Bulletin de l'Association des Anciens Elèves de l'Ecole Supérieur de Brasserie de Louvain.

Lindet, L.

Report on the Lighting and Heating Apparatus Entered in the Alcohol Competition of October and November at Paris, 1901. (Concours Général de Moteurs et Appareils Utilisant l'Alcool Dénaturé. Rapport du Jury de la Deuxième Section. Appareils d'Eclairage et de Chauffage.) Annales du Ministère de l'Agriculture, Paris, 21 année, No. 1, April, 1902, pp. 137-163, 18 figs, 5 tables, 6000 w.

This is the official report of the French competition of 1901, describing and illustrating the apparatus, and giving the results of the measurements of lighting power, consumption, etc. For report of the first section, motors and automobiles, see **Ringelmann, Maximilien;** for report of the committee on liquid fuels, see **Sorel, Ernest.**

Lindet, L.

Lighting and Heating with Alcohol at the Paris Competition, 1901. (L'Eclairage et le Chauffage par l'Alcool au Concours de 1901.) Bulletin de la Société d'Encouragement, pour l'Industrie Nationale, 101 Année, Tome 102, Feb., 1902, pp. 148-177, 18 figs, 8000 w.

A comprehensive illustrated paper describing and illustrating the different forms of lighting and heating apparatus tested, and giving the consumption under test.

This article is also printed under the same title in condensed form in Revue Générale des Sciences, Paris, 13 Année, No. 6 March 30, 1902, pp. 284-290, 5 tables, 3000 w.

In Le Génie Civil, Paris, Tome 40, No. 21, March 22, 1902, pp. 350-352, is given a résumé of this lecture in 1000 w. and 4 tables.

Lindet, L.

Lighting and Heating with Alcohol at the International Paris Competition of 1902. (L'Eclairage et le Chauffage par l'Alcool au Concours International de 1902.) Bulletin de la Société d'Encouragement pour l'Industrie Nationale, Paris, 101 Année, Tome 103, Aug., 1902, pp. 167-200, 16 figs, 10,000 w.

This article describes and illustrates both lighting and heating apparatus, gives tables and diagrams, showing consumption of alcohol under test, dealing especially with lamps provided with incandescent mantles for lighting.

An article entitled "Consommation des Appareils d'Eclairage et de Chauffage à l'Alcool," published in Le Génie Civil, Paris, Tome 42, No. 20, Mar. 14, 1903, page 317, 800 w., gives a résumé of the above article, stating the general conclusions obtained. There is also given a diagram by M. Laporte, illustrating the improvement in efficiency of alcohol lamps since 1899.

Longridge, C. C.

French Tests of Alcohol Motors. The Engineer, London, Vol. 96, No. 2482, July 24, 1903, pp. 85-86, 2 tables, 1 diagram, 1500 w.

A table of the results of the tests is given, and conclusions are drawn as to the advantages of slow speed, long stroke and high compression on fuel consumption and the disadvantage of governing by means of throttled admission.

Longridge, C. C.

French Research on Alcohol Motors. The Engineer, London, Vol. 95, No. 2475, June 5, 1903, pp. 576-577, 1700 w.

Discusses Sorel's report on the phenomena of combustion in stationary alcohol motors, considering the fuel used, effect of the fuel on the motor, analyses of the exhaust, quantity of air required for combustion, mixing of alcohol with other hydrocarbon fuels. Reference to the report discussed is given in this bibliography under **Sorel, Ernest.**

Longridge, C. C.

Alcohol Carbureters. The Engineer, London, Vol. 96, No. 2487, Aug. 28, 1903, p. 206, 1500 w.

A summary of French paper by Périssé and de la Valette. Classifies the French carburetors according to the means used for spraying the fuel and for furnishing the heat necessary for vaporization.

Longridge, C. C.

Theory of the Alcohol Motor. The Engineer, London, Vol. 96, No. 2484, Aug. 7, 1903, p. 143, 2000 w.

A discussion of the beneficial effect to be expected from the combination of a high initial compression, with a cool expansion due to the presence of water.

Longridge, C. C.

Phenomena of Alcohol Combustion. The Engineer, London, Vol. 96, No. 2492, Oct. 2, 1903, p. 324, 3 tables, 1 fig., 1700 w.

Describes a series of experiments bearing upon the chemical theory that the decomposition of the fuel improved the combustion and efficiency. Proposes the use of apparatus between the carbureter and engine cylinder to produce dissociation of the alcohol with formation of aldehyde to give more perfect combustion of the alcohol fuel.

Luedecke, and Güldner, H.

See Güldner, Hugo.

Marchis, Lucien René André Edmond.

Textbook on Motors, Automobiles, and the Industrial Applications of Alcohol to Heating, Lighting, and Motor Power. (Leçons sur les Moteurs d'Automobiles et les Applications Industrielles de l'Alcool au Chauffage, à l'Eclairage et à la Force Motrice.) Quarto, 570 pages, 200 text figures. Vve. Ch. Dunod, Paris, 1903.

This book contains a chapter on the physical and chemical properties of alcohol, one on alcohol motors and carbureters, and an appendix on lighting by alcohol. The French results of 1902 are included.

Mason, Frank H.

The Manufacture and Technical Uses of Alcohol in Germany. U. S. Monthly Consular Reports, Washington, Vol. 79, No. 260, May, 1902, pp. 78-87, 7 figs., 2000 w.

A brief discussion of the exposition of alcohol apparatus held at Berlin, February 8-16, 1902. It includes a brief illustrated description of heating and lighting apparatus, and alcohol engines and statistics relating to the consumption of industrial alcohol in Germany.

Meyer, Eugen.

Tests of Portable Alcohol Engines in 1902. (Die Hauptprüfung von Spirituslokomobilen 1902.) Arbeiten der Deutschen Landwirtschafts-Gesellschaft, Heft 78, Berlin, 1903, pp. 55, 35 figs, 11 tables.

This is the official report of the tests conducted on 10 different German alcohol engines at the establishment of the German Distillers' Association. This is the most important series of tests carried out in Germany on alcohol engines. The engines are described and illustrated and the results given in detail.

The results of these tests are reprinted with additional technical details and reproductions of indicator cards in Zeitschrift des Vereines der Deutscher Ingenieure, Bd. 47, No. 15, April 11, pp. 513-519; No. 17, April 25, pp. 600-606; No. 18, May 2, pp. 632-639; No. 19, May 9, 1903, pp. 669-673. This includes results of tests of a Diesel motor.

Mohr, D.

Results of Tests of Alcohol Lamps. (Die Ergebnisse der Hauptprüfung der Spirituslampen im Preisbewerb der Deutschen Landwirtschafts-Gesellschaft.) Zeitschrift für Spiritusindustrie, Berlin, 28 Jahrg., No. 23, June 8, pp. 227-229, and No. 24, June 15, 1905, pp. 235-236, 11 tables, 3000 w.

This is the report of the results of a competitive test of lamps, in which 11 different lamps submitted by 9 different manufacturers were investigated. The tables show for each lamp the candle power, the fuel consumption per hour, and the fuel consumption per candlepower hour.

Müller, W. A. Th.

Comparative Tests of Benzine and Alcohol in an Explosion Engine. (Vergleichende Versuche an einem Explosionsmotor mit Benzin und mit Spiritusbetrieb.) Zeitschrift des Vereines des Deutscher Ingenieure, Berlin, Bd. 47, No. 2, Jan. 10, 1903, pp. 59-62, 5 figs, 3000 w.

Results of consumption tests on the same engine using both benzine and alcohol at a series of different initial compressions.

Neuberg, Ernest.

The Alcohol Motor. Auto Motor and Horseless Vehicle Journal, London, Vol. 6, No. 5 (No. 65), Feb., 1902, pp. 194-196, 2 tables, 1700 w.

An account of the experiments in connection with the competition for alcohol motors, organized by the Mitteleuropäischer Motorwagen-Verein, and carried out in the gas engine laboratory of the Technical High School of Berlin.

Olchmann, A.

Alcohol Traction Engines for Agricultural Operations. A Report of Tests Made Under the Direction of the Implement Section of the German Agricultural Society. (Spiritus-kraftwagen für den landwirtschaftlichen Betrieb. Prüfungsbericht auf Veranlassung der Deutschen Landwirtschafts-Gesellschaft Geräte-Abteilung.) Arbeiten der Deutschen Landwirtschaft-Gesellschaft, Heft 86, Berlin, 1903, 84 pp, 86 figs.

A detailed description of the design, appearance, use and operation of numerous types of traction and portable alcohol engines developed in Germany.

Ormondy, W. R.

Alcohol as a Fuel for Motor Cars. Autocar, Coventry, Eng., Jan. 14, 1905, 2300 w.

An interview with Dr. Ormondy discussing why alcohol is not more generally used, its advantages, the working of the alcohol engine, etc.

Ormondy, W. R.

Alcohol as a Motive Power. The Engineer, London, Vol. 97, No. 2520, April 15, 1904, p. 399, 3000 w.

An abstract of a paper before the Automobile Club, Mar. 24, 1904. Discusses advantages and disadvantages of alcohol, and reviews history of development in France and Germany.

Ormondy, W. R.

Alcohol as a Fuel for Motors. A paper before the Western Section of the Scottish Automobile Club. Automobile, New York, 1200 w. Vol. 12, No. 24, June 15, p. 719; No. 25, June 22, 1905, pp. 746-747. Reprinted, omitting the discussion, in The Gas Engine, Cincinnati, Vol. 7, No. 7, July, pp. 218-219; No. 8, Aug. 1905, p. 260.

This article discusses the heat required to vaporize alcohol, the range of its explosibility, its boiling point, and the advantage of alcohol as a fuel.

Ormondy, W. R.

Alcohol as a Motive Power. Motor Car Journal, Apr. 2, 1904, 5000 w.

Arguments showing alcohol to be a suitable motor fuel, and in some respects the most suitable fuel, and giving proofs of its practical possibilities.

Périssé, Lucien.

Alcohol for Power. Mémoires de la Société des Ingénieurs Civils de France, Paris, 1899 Année, 2. Vol., No. 6, June, 1899, p. 932, 1500 w.

A summary and discussion of a paper before the society detailing the progress made in adapting alcohol to use in internal combustion motors.

Périssé, Lucien.

The Alcohol Motor. Scientific American Supplement, New York, Vol. 52, No. 1356, Dec. 28, 1901, p. 21,738, 800 w.

A brief discussion of best consumption results obtained in European countries up to the date of the article. A translation of an article entitled "L'Alcool Moteur." La Nature, Paris, 29 Année, 2. sem., No. 1486, Nov. 16, 1901. pp. 380-387.

Périssé, Lucien.

Alcohol Motors. (Les Moteurs à Alcool.) Mémoires et Compte Rendu des Travaux de la Société des Ingénieurs Civils de France, Paris, Année 1901, 2. Vol., No. 7, July, 1901, pp. 25-95, 14 figs., 11 tables, 15,000 w.

An exhaustive study of the construction and operation of internal combustion motors using alcohol as fuel, under the following headings: Importance of alcohol as a national product; Physical and chemical properties of alcohols, pure, denatured, and carbureted; Statistics of, and laws and taxes affecting alcohol; Descriptions of carbureters and motors; Tests of stationary alcohol motors and automobiles, efficiencies and costs. A history of all the investigations that had been made on alcohol motors up to that time is given. The following carbureters are described, and most of them illustrated: Pétréano, Martha, Le Blon, Longuemare, Delahaye, Richard, Société Marienfeld, Koerting, Dion-Bouton, Duplex, Gobron-Brillié. The results of all tests previously made in Germany and France are given and compared.

Périssé, Lucien.

Carbureters. (Les Carburateurs.) 12mo, 173 pages, 16 figs. (Encyclopédie Scientifique des Aide-mémoire.) Gauthier-Villars, Paris, 1904.

Contains one chapter devoted to carbureters suitable for use with alcohol.

Périssé, Lucien.

A Comparative Technical Study of Denatured Alcohols. (Etude Technique Comparatives des Alcools Dénaturé, Vienne, 1904.) Mémoires de la Société des Ingénieurs Civils de France, Paris, année 1905, 1. Vol., No. 2, Feb., 1905, pp. 291-321, 3 figs., 10,000 w.

Describes the methods of testing, and gives the results obtained at the Vienna exposition in power of internal-combustion engines using denatured alcohol as fuel, using alcohol from France, Germany, Austria, Russia and Switzerland denatured according to the practice in the different countries.

Périssé, L. and H. de la Vallette.

Alcohol Carbureters. (Les Carburateurs à Alcool.) Compte Rendus du Congrès des Applications de l'Alcool Dénaturé, Paris, 1902, pp. 166-177, 14 figs, 3500 w.

A discussion of the conditions to be met by successful alcohol carbureters, and descriptions and illustrations showing how these conditions are complied with in actual carbureters.

Périssé, Raymond.

International Alcohol Exposition of Lighting and Heating Apparatus. Scientific American Supplement, Vol. 54, No. 1399, pp. 22-421, Oct. 25, 1902, 4 figs., 1500 w.

A description of the exhibits at the Paris exhibition of May, 1902. A translation of an article entitled: "Concours International de l'Alcool. Eclairage et Chauffage." La Nature, Paris, 30 année, 2. sem., No. 1520, July 12, 1902, pp. 83-86, 5 figs.

(To be concluded.)

INVESTIGATIONS ON RADIUM

During the past year speculation as to the ultimate nature of radium and its congeners has continued, but perhaps rather more languidly than before. Madame Curie, using radium chloride containing not more than 0.1% of barium chloride, has found the value 226.45 for the atomic weight of radium, taking 107.93 and 35.45 as the atomic weight of silver and chlorine respectively. The metal radium itself is still unknown. Lord Kelvin, in an endeavor to explain the cause of the radio-activity of radium, leans to the view that the energy required for the loading of the radium atom, by virtue of which its most characteristic properties exist, is acquired by a cooling of the atom in the course of its activity, and a consequent transference of heat from external sources to itself. Accepting this, it would appear that disappearance of activity will not occur until the atom has lost its power of absorbing external energy, that is, until it is disintegrated. The amount and distribution of radium in the earth's crust continue to occupy physicists and geologists, whose arguments are inconclusive because of their poverty in experimental basis. Prof. Joly suggests that the source of radium is external to the earth, and that the radium is picked up by the globe in its passage through space, and adds, with candor, that this view is arrived at by a process of exclusion. The properties and fate of the emanation have been the subject of remarkable researches by Sir William Ramsay. The emanation decomposes water, and the evolved gases contain more than their normal proportion of hydrogen; the reason for this excess is obscure. The emanation obeys Boyle's law. According to previous investigation the emanation per se changes into helium; now it is found that its ultimate products depend on the nature of the material with which it is in contact, for with water it gives helium, and with copper nitrate yields argon and a trace of lithium and probably sodium. The hypothesis is put forward that the products of degradation depend on the molecular size and complexity of the companions of the down-going individual. When the small quantity of material available for the experiments on which these speculations depend is considered, one is at a loss whether to admire more the skill of the chemist or his courage.—"The Engineer," London.

THE STERILIZATION OF DRINKING WATER BY HEAT

CONDENSED FROM "ENGINEERING NEWS"

There is great need for some apparatus or method which will furnish pure drinking water at low cost in localities where the existing water supply is impure, and where the installation of purification plants on a large scale is not practicable.

Engineers and sanitarians have long had their attention concentrated on the supply of pure water to the dwellers in towns and cities. But a great proportion of the population does not live in cities. With all the amazing growth of our great cities, fully half the people of the United States still live under rural conditions. The prevalence of typhoid and other water-borne diseases among these isolated dwellers in the country is very great; and in many sections it is almost impossible to obtain pure potable water for drinking. And while we look forward to the time when every large city shall have its filtration plant, that time is still far distant; and meanwhile there is a great need among city dwellers for absolutely pure drinking water.

These are the conditions in the temperate zone; but when we turn to the tropics we find conditions even more serious. Recent investigations have shown the principal tropical diseases to be chiefly transmitted by impure water and by mosquitos. If the American or Englishman living in the tropics will drink sterilized water and protect himself from mosquitos, he can live in the tropics almost as safely as at home.

There are readily available numerous ways of securing a perfectly safe drinking water for any person or group of persons to whom a city-filtered water supply is not accessible. But under a wide range of conditions, which need not be reviewed here, it often happens that the most practicable, and, at the same time, the surest means of making drinking water safe, is by the application of heat. Sterility can be secured by distillation or by long-continued boiling, repeated at intervals of several days. But for the destruction of the disease germs common to water, absolute sterility is not required. After having been either distilled or boiled for any considerable period water has an objectionable, flat, insipid taste, because the gases normally contained in the water are driven off by the heat. Either boiled or distilled water must be cooled before it can be used. While boiled or distilled water may be aerated to improve its taste, it is difficult to do this on a small scale, and there is risk that the process may contaminate the water with germs.

There is, however, one method of treating water which is free from these objections. That is the application of heat to water in a closed receptacle, so that the contained gas will not be driven off, and with apparatus so arranged that the stream of water leaving shall impart its heat to that entering, thus enabling the process to be carried on with only a small amount of heat. In such an apparatus the pure water delivered should retain its original gases and consequent agreeable taste, and it should be at a temperature not far above that at which it entered. While such water is not

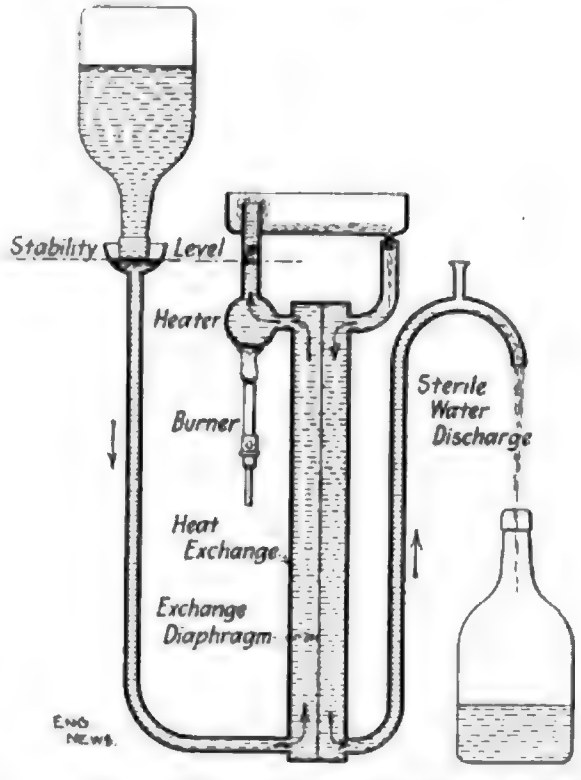

FIG. 1. FORBES WATER-STERILIZING SYSTEM, SIMPLIFIED DIAGRAM SHOWING PRINCIPLE OF OPERATION.

Fig. 1.

Fig. 1 shows a section of the cornice of the Temple of Jupiter Stator, which is the oldest example of the Corinthian order in Rome. The cornice is of travertine, and the modillions are carved with acanthus leaves. The cornice is crowned with a cyma reversa moulding, and the bed-mould is carved with egg-and-dart. The frieze is plain, and the architrave is divided into three fascias. The whole is supported on a plain entablature.

sponding to the heat desired. Thus any predetermined degree of heat may be used in treating liquids.

Two general, distinctive types have been developed: (1) The diaphragm apparatus; (2) the tubular apparatus. The various minor modifications of these two general types provide apparatus for any capacity and means of operating, under all possible conditions.

The tubular apparatus is of a much more substantial character than the diaphragm types, and is intended for severe service sustained for long periods. This type is built for capacities of 50, 150, 250 and 500 gals. per hr., and is steam-operated.

As to principle of operation this type follows Fig. 1. From the level-regulating chamber the water is carried to the bottom of the heat exchange, where it enters above a tube sheet and fills the shell surrounding the tubes. Flowing over into the heater chamber, it rises inside the hood surrounding the heater tubes. When steam is supplied to the heater tubes the water boils over into the pan at the top, whence it flows down through the tubes of the heat exchange. The action thereafter is the same as in the diaphragm apparatus. Steam at a very low pressure will maintain this type in continuous operation. Exhaust steam at 1-lb. pressure has been found sufficient in actual use.

In both general types the design and construction of parts are carried out with care as to metallic contamination of the water.

The shells are of copper and brass, lined with block tin. In the diaphragm type the diaphragm is of sheet copper, tin-coated on both sides. In the tubular apparatus the tubes are of seamless brass, tin-lined.

In all of the apparatus ample means are provided for inspecting and cleaning the surfaces, but in practical operation it has developed that scale and deposits do not accumulate, as might be expected. The only point where any sign of scale has been found, after long tests, is in the heater of the gas or kerosene operated apparatus; in the steam-operated apparatus the nearest approach to scale which has developed in actual use is a soft, puttylike deposit on the heater tubes, easily washed off. Any precipitation of salts in the heat exchange partakes of the nature of a sludge, and is easily drawn off through the wash-out cocks.

Economy of the Method.—Naturally, the question arises: How cheaply may sterilization be accomplished with this apparatus? Owing to lack of space, we can give but a general idea; but the following figures, furnished by the manufacturers and based upon practical tests, are of considerable interest.

In the larger apparatus, where the ratio of heat-transfer surface to the exterior surface is large, suitable insulation reduces radiation losses to a negligible quantity. With apparatus operated at a normal rate, the sterile water can be delivered at a temperature not more than 5° above the entering raw water. Therefore, neglecting radiation losses, there will be necessary, after the contents of the apparatus are heated, 5 B.T.U. per lb. of water treated. Allowing 10,000 available B.T.U. per pound of coal, 2,000 lbs. or 240 gals. of water may be treated per pound of coal burned.

This efficiency, with coal at $3.00 per ton as a basis, represents a cost for fuel alone of $6.24 per 1,000,000 gals. of sterilized water. In localities like Pittsburg or Scranton, where usable coal can be obtained at $1 per ton, this low cost is materially reduced. Under the ordinary method of boiling water and allowing it to cool naturally, all heat thrown off in cooling is of course lost, so that 1 lb. of coal will sterilize only about 58 lbs. or 7 gals. of water.

Special Army Apparatus.—A portable army plant for furnishing safe drinking water to troops in the field has been built for the United States government. It has a capacity of 400 gals. per hour, and is in full operation 11 minutes after starting; it is mounted on a steel frame truck and weighs about 3,150 lbs.

FIRELESS (STEAM ACCUMULATOR) LOCOMOTIVES

The fireless locomotive, according to Capt. Godfrey L. Carden, of the United States Revenue Cutter Service, in a recent letter to the "Daily Consular and Trade Reports," is practically the only type of motor power which can be recommended for plants where the question of fire precaution is almost a first consideration, as, for example, powder mills, cotton plants, wharves, and other places where the presence of an ordinary type of locomotive, or even electric power, prejudices the insurance. It is, of course, unsuitable for uninterrupted

railway service, being essentially a yard switching machine, and it must keep near its base of supply, which is the boiler of some local power station.

Speaking generally, a fireless locomotive is really an accumulator engine, the boiler being about three-quarters filled with water, which is heated by means of steam at a pressure of about 170 lbs. per sq. in. to about 375° F. It takes from 8 to 15 minutes to refill the boiler with water and heat it with steam from the power-house boiler, and the drop in pressure in so doing is only about 7 lbs. The locomotive is then a boiler partly filled with highly heated water which gives off steam initially at about 170 lbs. pressure, the pressure, however, constantly decreasing as the locomotive is operated. It is found in practice that considerable work can be accomplished even when the pressure has fallen as low as from 15 to 30 lbs., and that it is possible for the locomotive to work its way to the filling tank, or power-house boiler, under its own steam, when the pressure is no higher than from 5 to 7 lbs. Summed up briefly, this type of engine offers absolute safety against fire which might be caused by flying sparks and all smoke nuisance is eliminated. This permits of the machine being used in sheds and other inclosures. There is marked economy, since the cost of producing steam in stationary boiler plants is less than when produced by ordinary fire locomotives. Only one man is required to run the engine, and when the machine is not in operation the services of this man can be utilized elsewhere. Practically there are little or no repairs needed on one of these machines, since there is no fire box the strain on the boiler is practically nil. Any incrustations which may develop need not be removed, as such deposits, by serving as calorifuge, assist in reducing the radiation of heat. The engine can be made ready for service in a very short time, and when once charged is ready for work at a moment's notice. If it is not required constantly the machine may be left standing without supervision, and even after the expiration of several hours it can be brought into play. From this it will be seen that the special province of this type of machine is interrupted work. Since the machine is independent of electric current it can be operated over any line of tracks adapted to its gage, and in point of safety it is probably unexcelled. There need be no fear of an explosion as the steam tension in the receiver after filling up only decreases and never increases.

The steam quantity which theoretically may, subject to temperature limits, be taken from the hot-water boiler, works out according to the following formula:

Let P_1 represent the water quantity and t_1 the temperature of the water in the boiler after it has been newly filled, P_2 the water quantity and t_2 the temperature in the tank after the work has been completed; the quantity of heat at the beginning will then be $P_1 t_1$ and at the end $P_2 t_2$; the difference between $P_1 t_1$ and $P_2 t_2$ has been employed for the evaporation of the water quantity $P_1 - P_2$.

Further, if r stands for the latent heat of evaporation at a medium temperature, the following equation will be obtained, and the result will be:

$$P_1 t_1 - P_2 t_2 = P_1 - P_2) r,$$
$$P_2 = P_1 (r - t) / (r_1 - t_2).$$

At given temperature limits it is therefore possible to estimate the final water quantity out of the initial water quantity.

In one type of engine made by A. Borsig, of Tegel, Germany, known as No. 6, the locomotive boiler has a capacity of 9 cubic meters. This boiler holds, therefore, about 7,000 liters of water (1,840 gals.). Supposing a steam pressure of 12 atmospheres in the stationary boiler plant, the initial pressure in the receiver may then be supposed to be 11 atmospheres (156.5 lbs. per sq. in.). Should the working capacity of the heated water be utilized to such an extent that the tension in the receiver is reduced to 2 atmospheres (28.5 lbs.), the following quantity of steam, in conformity to the above formula, will be required for the refilling of the receiver until the initial tension of 11 atmospheres will be arrived at:

$P_3 = 7{,}000\ [(497.5 - 183)/(497.5 - 119.6)] =$ 5,824 kgs. of steam; and 7,000—5,824 = 1,176 kgs. of steam required (2,587 lbs.).

At a steam consumption of 22 kgs. per HP.-hour (or 48.4 lbs.,—a figure based on numerous tests and taking into consideration the loss of test through leakage and radiation), the locomotive, when being filled up to the above indicated tension limits, may have an efficiency of 53 HP.-hours. Consumption, as well as the efficiency of any fireless locomotive may be estimated, it is stated, on this last formula, in any case which arises.

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COMPRESSED AIR CALCULATIONS*

By E. A. RIX, M. Am. Soc. C. E.

FROM "THE JOURNAL OF ELECTRICITY, POWER AND GAS."

Before we undertake to solve a problem which I shall present for your consideration, I shall give you some of the practical data which I use to make these calculations.

During the last twenty years, I have kept a log of all the compressed air plans I have tested, and also the actual performance of a great number, covering almost every kind of compressor and compressed air motor or tool, and I have averaged all the indicator cards taken from the various compressors used in mining work and compared the indicated horse-power with the actual power required, comparing this with the displacement of the compressor cylinders, I have concluded that for a safe and sane power factor, we must allow 20 B.HP. for every 100 cu. ft. of cylinder displacement, to compress air from atmospheric pressure to 90 or 95 lbs. receiver gage pressure at sea level.

I have made my calculations on these pressures because they are the standard pressures now used for pneumatic work, and nearly every machine and motor is constructed for these pressures. It may also be noted that it would be just as well in small plants (up to 400 cu. ft. capacity) to make no distinction between single and two stage machines.

If you consult tables in any engineering magazine or trade catalogue, on air compressors, you will note that the power claimed to do certain work is much less than the figure which I give you, and in explanation, it must be noted that these tables are theoretical, and do not take into account the mechanical efficiency of the compressor, nor losses due to volumetric efficiency of compressors.

These figures are, therefore, misleading, and should be avoided except to use as comparisons between one machine and another.

A compressed air cylinder will never give a quantity of air equal to the volume swept by the piston, for the reason that such things as clearance, leakage, temperature, piston speed, etc., reduce the theoretical quantity so that it is best to figure about 80% volumetric efficiency for the average mining compressor. Many do not give 60% and some 90%.

In using compressed air at 90 lbs. pressure cold, it will take 24 cu. ft. of free air per minute to give 1 HP. in plain slide-valve engines, and 15 cu. ft. with good expansion-valve gearing, and between these two limits will lie all the various types of engines. If the air be reheated, to about 300° F., it will reduce the above quantities about one-third. In one hoisting engine which we installed, having compound Corliss cylinders, and where the air was heated to 400° F. before entering each cylinder, it required between 7 and 8 cu. ft only for 1 HP. Most mines, however, use cold air and prefer the power loss to the trouble and expense of the installation and maintenance of reheating apparatus.

The tables set forth in the trade catalogues for the air consumption of standard piston rock drills are fairly accurate and are generally in terms of the compressor cylinder displacement.

For operating ordinary station and sinking pumps of the direct-acting type, which is the ordinary stock pump usually used in mining operations, it will be safe to calculate that 1 cu. ft. of free air compressed to 90 lbs. gage pressure will do 135 foot-gallons of pumping.

Ordinary mining hoists have a mechanical efficiency of about 75%.

For the determination of pipe sizes, losses of pressure and terminal pressures for compressed air transmission, I use the Johnson formula, which is very satisfactory:

$$P_1^2 - P_2^2 = 0.0006\, V^2 L / A^5 \quad \ldots\ldots (1)$$

Wherein P_1 = absolute initial air pressure.
P_2 = " terminal air pressure.
V = free air equivalent passing through the pipe.
L = length of pipe in feet.
A = diameter in inches.

This formula is quite simple to solve.

With these facts at hand, we can now readily calculate the problem we shall consider as follows:

A mine having a water power distant 5,000 ft. wishes to generate compressed air and transmit it to the collar of the shaft for operat-

*Slightly condensed from a paper read before the Mining Association of the University of California, Feb. 19, 1908.

ing purposes. The work to be performed is as follows:

100 tons of ore and waste to be hoisted in 20 hours.

30 gals. of water per min. to be pumped either at a station or a sinking pump.

5—2¼ standard piston rock-drills to be operated.

3 air-hammer drills to be operated.

General Conditions:

Depth of shaft, 600 ft.

Weight of skip and rope, 1,000 lbs.

Weight of ore hoisted, 1 ton.

Initial air pressure, 95 lbs.

Final air pressure, 90 lbs.

Altitude, sea level.

Geared hoist and unbalanced hoisting.

Required:

Size of compressor.

Diameter of air pipe.

Brake horsepower.

Altitude factors.

Reheating coefficients.

[Note.—In problems of this kind, we must reduce all of our requirements to cubic feet of free air because free air is the basis for all power calculations.]

SOLUTION.

Free Air Required for Hoisting.—If 100 tons of ore and waste are to be hoisted in 20 hours a 1-ton load will be hoisted every 12 minutes. Of course, we know that an absolute schedule of 12 minutes between hoists can scarcely ever be carried out, but the only way to figure it is on a regular basis, and after that is determined, allowance one way or another can be made for any irregularity.

The load being 2,000 lbs. of material and 1,000 lbs. of rope and skip, makes a total of 3,000 lbs. which is to be hoisted 600 ft. Three thousands pounds lifted 600 ft. will require 1,800,000 ft.-lbs. of work, or 54 HP., theoretical. Inasmuch as the hoist has a probable efficiency of 75%, the 54 HP. becomes 72 B.HP. actually required.

Using cold air, it requires, as we have mentioned before, 24 cu. ft. of free air per horsepower. Then $24 \times 72 = 1,728$ cu. ft. of free air which the hoist will consume to make one lift. This, you will note, gives us direct results without taking into consideration the element of time or the dimensions of the hoist. If we made a hoist every 12 minutes, and it required 1,728 cu. ft. to make a hoist, then the compressor must furnish 144 cu. ft. of free air per min. continuously, and we must have storage capacity sufficient to accumulate the air between hoists. Right here is the vital point of hoisting economically with compressed air.

Let us assume that we hoist at the rate of 300 ft. per min.; then it will take two minutes to make the lift, and the hoist will be lowering and idle during the next ten minutes. During this ten minutes, the compressor is delivering 144 cu. ft. of free air per min., or 1,440 cu. ft. total, which must be stored.

If the hoist is none too large for the work, you will find that if the pressure in the receiver drops more than one atmosphere or from 90 lbs. to 75 lbs., that the hoist will not operate in a satisfactory manner. Then, in our problem, if we must draw 1,440 cu. ft. from the receivers at a drop of one atmosphere in pressure, the receivers must have a cubic capacity of 1,440 cu. ft. and if the hoist is amply large so that it will still operate after the receiver pressure has dropped two atmospheres, or from 90 lbs. to 60 lbs., then the receiver capacity can be one-half of 1,440, or 720 cu. ft., but it is not wise to go below this pressure, because it will affect too materially the pressure required for operating the other machinery.

For a first-class job, install receivers having a capacity equal to the storage required at one atmosphere pressure. Large receivers cost less in proportion to their storage capacity than small ones. For example: A carload consisting of four receivers 54 ins. in diam. by 30 ft. long, containing about 2,000 cu. ft., costs at the present time about $1,600, while the same storage in ordinary receivers 48 ins. in diam. and 12 ft. long, would cost about $2,200. It is better to invest more money in receivers and less in compressors, because the smaller compressor take less power at the peak, and most power bills are figured on a constant peak.

If you install a plant and the receiver capacity is too small, you can always determine the proper quantity of storage by running the compressor with the unloader cut out, and if the receivers blow off between hoists and the pressure drops more than 15 lbs. during hoisting, add more receiver capacity until it will not blow off nor drop more than 15 lbs. If you arrive at the point where it does not blow off and the pressure does not fall to 15 lbs., then slow down the compressor until the desired drop is reached, and you will be operating your plant at the most economical point. Then cut in the unloader again and let it work when it will. An unloader only saves wear and tear on the compressor where you buy power at the

peak load, as happens in most cases, but does not affect your power bill.

Let us go back now to our problem. We find, therefore, that 144 cu. ft. per min. is required for hoisting. Now, while we have allowed four hours in twenty-four, or an hour and twenty minutes on each shift for hoisting and lowering men, timbers, supplies, etc., it is entirely probable that at least once every hour some one will be going up and down the shaft, and it would be practical, therefore, to say that the hoist would handle six loads per hour instead of five, and we must therefore add 20% to the hoisting requirement, making, say, 175 cu. ft. instead of 144.

Amount of Compressed Air Required for Pumping.—For pumping 30 gals. per min. 600 ft., requires 30 × 600 or 18,000 ft.-gals. of work. If one cubic foot of free air at 90 lbs. gage pressure will give 135 ft.-gals. of work, we shall require 133 cu. ft. of free air for the pumping. This requirement is constant.

Amount of Compressed Air Required for Drilling.—Five 2¼-in. rock drills will require 50 ft. of free air each, or 250 cu. ft., and three air-hammer drills will require 25 cu. ft. each, or 75 cu. ft. To get these amounts, take about 80% of the requirements as stated in rock-drill catalogues, which always give quantities in compressor-cylinder displacement which do not deliver on an average within 20% of their displacement, excepting in large machines.

Our total requirements will therefore be:

Hoisting	175 cu. ft.
Pumping	133 cu. ft.
Drilling	325 cu. ft.
Total	633 cu. ft.

This 633 cu. ft. does not take into consideration any ordinary pipe leakage in the hoisting works and below ground, and in conducting this air from a distance, inasmuch as our problem calls for a transmission of 5,000 ft., it would be well to allow a leakage of 5% on the entire system. This would bring our requirements up to 665 cu. ft., and if we allow that our compressor will give a volumetric efficiency of at least 80%, we must have a cylinder displacement of 830 cu. ft. per min.

You will remember that our power factor was 20 HP. per 100 cu. ft.; consequently we must have 166 HP. delivered on our waterwheel shaft to drive this compressor.

Finally, we must determine the size of the pipe, allowing 5 lbs. drop in pressure for friction loss. In the formula (1), P_1 the initial pressure absolute = 95 + 14.7, or 109.7, and its square is 12,034.

P_2 the terminal pressure we have stated shall be 5 lbs. less than the initial or 90 lbs., or 104.7 absolute, and its square is 10,962.

The difference between these two, or—

$$P_1^2 - P_2^2 = 1{,}072.$$

Substituting this in our equation, and also the values for L and V (L = 5,000, V = 633), and solving for A, we have A, or the diameter of the pipe = 4 ins.

We have now to figure the size of the compressor required. If you happen to have tables and catalogues at hand, it will be an easy matter to look up a satisfactory compressor having a displacement of 830 cu. ft., but if such literature is not at hand, the size of the compressor may be determined as follows:

It almost goes without saying that you would select a two-stage compressor for anything over 400 cu. ft. capacity. This two-stage compressor will have a low-pressure or gathering cylinder, wherein the air is compressed to about 25 lbs., and a high-pressure cylinder where the air at 25 lbs. after it has been cooled will be compressed to 90 or 95 lbs. pressure. The reason a two-stage machine is selected is because it has a higher volumetric efficiency, requires less power to operate it, is easier to lubricate on account of lower temperatures and has less strains on the mechanism.

The first thing to consider is the speed at which you will operate the compressor, and this will be dictated by many things. If you have a limited amount to expend, you will naturally select as high a working speed as possible, because the higher the speed, the smaller the compressor.

Again, you may have to take the future into consideration, and you may want more air later on, as the shaft goes deeper or more water is encountered. You would then naturally select such a speed as would give you the margin of additional power required.

You may take 150 r.p.m. as the maximum for compressors from 400 to 1,500 ft. capacity, and 100 r.p.m. as a speed that will give you a 50% margin for the future, so let us assume that the mine in question has a future, and take 100 r.p.m. If our requirement is 830 cu. ft. per min. we shall then require an intake or compression cylinder which will give us 8.3 cu. ft. per revolution, and inasmuch as the cylinder is double-acting—that is to say, makes two displacements per revolution, the cylinder must have a cubic capacity of 4.15 cu. ft.

Experience dictates that the average compressor cylinder is built for the following strokes and capacities:

6-in.	stroke	up to	50-ft.	capacity.
8-in.	"	"	100-ft.	"
10-in.	"	"	200-ft.	"
12-in.	"	"	500-ft.	"
16-in.	"	"	700-ft.	"
18-in.	"	"	1,500-ft.	"
24-in.	"	"	2,500-ft.	"

Our compressor will therefore be best suited by an 18-in. stroke, or 1.5 ft. If the capacity is 4.15 cu. ft. and the stroke 1.5 ft., the area of the cylinder will be $\frac{4.15}{1.5} = 2.75$ sq. ft., or 397 sq. ins., which is the area of a 22½-in. cylinder. The low-pressure cylinder will therefore be 22½ × 18.

It is very evident that if we have two cylinders to do our compressing, that there is no good reason why one cylinder should do more work than the other, and there is a very good reason why the work performed by these cylinders should be equal, viz.: because the total work and temperature developed will be at a minimum, just why—would lead us into mathematics, and so you must take the statement as a fact.

There is also the mechanical reason that the strains on the machine will be at a minimum, and if you construct the compressor of the duplex type, both sides will be alike, except as to the cylinders. If our two cylinders perform equal work, the intermediate pressure must be a mean proportional between the initial absolute pressure and the final absolute pressure, and the cylinder ratios will be as the ratios of either the high or initial absolute pressure to the intermediate. In other words,

If P = absolute initial pressure
P_1 = absolute intermediate pressure
P_{11} = absolute final pressure
then $P_1 = \sqrt{P \times P_{11}}$

Take our example: Our initial pressure is atmospheric or 147 absolute. Our final pressure is 95 lbs. gage or 109.7 absolute. The intermediate pressure will then be $P_1 = \sqrt{14.7 \times 109.7}$ or 40 lbs. absolute = 25.3 lbs. gage pressure. Our proportion then stands 14.7:40: :40:109.7, which represents a ratio of 40/14.7 or 109/40 = 2.74. The cylinder ratios will therefore be identical with the pressure ratios and our high-pressure cylinder will have a capacity of 1/2.74 of the low pressure. The strokes being the same, the area of the high pressure cylinder will be 1/2.74 of the low pressure, which was 397 sq. ins. Dividing this by 2.74, we have 145 sq. ins. as the area of the high-pressure cylinder. This corresponds to a diameter of 13½ ins. The compressor will then be a 22½-in. × 13½-in. × 18-in. stroke, and you will be justified in taking the nearest size to this that the manufacturers can supply.

You will note that as the altitude increases, the initial absolute pressure diminishes, and as the final pressure remains the same, the pressure ratio grows larger as the altitude increases. For example: At 10,000 ft. the atmospheric pressure is 10 lbs. instead of 14.7 lbs., and if you go through the same calculations that we have just made, you will find that the cylinder ratios will be 3.3 instead of 2.74, and this will make the high-pressure cylinder only 12½ ins. in diameter instead of 13½ ins., and the intermediate pressure will be 18.3 lbs. instead of 25.3 lbs. Such a compressor would not, however, be able to do the work contemplated in the problem we have considered, for the reason that while the weight of air necessary to do work remains practically the same for reasonable altitudes, the capacity of the compressor diminishes as the altitude increases. It is true the volume remains the same, but it has not the weight and therefore you must increase the size of the cylinder required at sea level by the ratio between the ratio of compression at sea level and the ratio of compression at altitude.

In our problem, the ratio of compression at sea level is 7.5 and the ratio of compression at altitude of 10,000 ft. is 11. The sea-level compressor must be increased therefor, 11/7.5, or 1.47 times, to give the same weight of compressed air at 10,000 ft. altitude, or, to put it even more simply, it will take 11 strokes to give same compressed air or to do the same work as 7½ strokes will do at sea-level.

In our problem this would make a low-pressure cylinder of 27 ins. instead of 22½ ins. and a high-pressure cylinder of 15 ins. instead of 13½ ins. In other words, this altitude compressor is nearly 50% larger to do the same work.

A proper understanding of these simple calculations will enable you to check up compressor sizes and proportions, and no one could furnish you with a sea-level compressor for an altitude one, and vice versa. We have

assumed a volumetric efficiency of 80% in this problem, but if the compressor happens to be a slow-speed, mechanical-valve machine, 90% could be assumed. The figures I have given you are safe, and taken from average plants, and it will be necessary for you to use your judgment in assuming a higher or lower factor.

Amount of Compressed Air Required for Reheating.—It is practical to reheat air from 300° to 400° F. in various ways and great economy realized, especially for pumping and hoisting, and if it is possible you may reduce the quantities of cold air which we have figured for this work by the ratio of the atmosphere to the compressed air temperature absolute. Thus, if the atmosphere is at 60° F. or 520° absolute, and the compressed air is used at 300° F. or 760° F. absolute, then the cold air volume for your work may be taken at the ratio of 520/760, or about 70%, thus making a saving of 30%.

EXHAUST STEAM TURBINES

CONDENSED FROM ARTICLES IN "THE ENGINEER," LONDON

The system of developing power by utilizing the exhaust from steam engines in low-pressure turbines, invented by Professor Rateau, about the year 1900, is the only one of its kind which has hitherto been applied, and by its means the efficiency of steam engines can be greatly increased. M. Rateau's original idea was to turn to profitable account the immense quantities of steam escaping to waste into the atmosphere, from large mines and factories, and from which it seemed to him possible to obtain considerable additional motive power. For this, however, an engine in which low-pressure steam could be efficiently utilized was essential, and until the introduction of steam turbines such an engine did not exist. Another difficulty was that the main engines in steel works and mines, which have the largest consumption of steam, are worked intermittently, and some means of regulating the flow of exhaust steam was therefore an indispensable condition of success.

In the course of his studies M. Rateau, having been led seven years ago to design a steam turbine capable of giving a very high efficiency, proceeded to embody his inventions in an experimental plant at the Brouay mines in August, 1902. The applications of his method have since increased year by year, and in October, 1907, 80 installations were at work, or in course of construction. The total power thus utilized, and formerly wasted, amounts to 70,000 HP.

The non-condensing engines generally used in mines and steel works operate at a steam pressure of about 118 lbs. per sq. in., and the theoretical consumption of steam per hour is 16.7 lbs. per HP. If the engine exhausts into a condenser in which the absolute pressure is 1.6 lbs. per sq. in., the theoretical steam consumption equals 10.3 lbs. per HP.-hour.

According to these figures, the economy in the consumption of the engine obtained by thus condensing the steam should be 46%, but it is well known that in practice it is scarcely ever 25%, and does not on an average exceed 15%; this considerable difference shows that when reciprocating engines are worked with low-pressure steam there are heavy losses, which do not occur with high-pressure steam.

It is also well known that with low-pressure steam only a relatively small part of the expansive force of the steam can be utilized. However large the cylinder, it is never large enough in practice to allow expansion to be complete, and even if it were possible to make it of the necessary dimensions, it would still only give a relatively poor efficiency. If, however, instead of a reciprocating engine a turbine be used, the working conditions are altered, because low-pressure steam can be completely expanded, and the vacuum formed in even the best condensers utilized to the best advantage. With the considerable speed of discharge in these engines, and the immense outlet capacity resulting from it, it is quite possible to have a turbine utilizing a flow of many thousand pounds of low-pressure steam, and yet retain its dimensions within moderate limits.

On the other hand, the lower the pressure of the steam, the higher the efficiency of the turbine, because the losses due to friction of the wheels in the steam, and leakage through the joints between the fixed and the rotary parts are diminished. These two sources of loss being sensibly in proportion to the specific

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weight of the fluid, the larger the specific volume of the latter, the smaller will they be.

In successively utilizing a reciprocating engine and a turbine, the object being to expand the steam as completely as possible from one end of the engine to the other, we shall base our calculations on the best working conditions, while keeping within the limits of modern every-day practice, and take a compound or a triple-expansion reciprocating engine, working at a high admission pressure of 235 lbs. per sq. in., in a good vacuum of 96%, and steam superheated to a temperature of 350° C. (660° F.). The corresponding theoretical steam consumption will be 5.8 lbs. per HP.-hour.

In the first case, with non-superheated steam in a non-condensing engine, the coefficient of heat utilization is 25.4%, and in the second, using superheated steam, the coefficient is 33%.

Assuming that the efficiency of a high-pressure reciprocating engine and a low-pressure turbine (i. e., the ratio of work at the end of the crank shaft to theoretical work) does not exceed 76%, it is possible under these conditions to utilize $0.33 \times 0.76\% = 25\%$ of the heat contained in the water.

This result compares favorably with that obtained in gas engines; the corresponding consumption of steam would be 7.7 lbs. per B. HP.-hour. (Note that if an efficiency of 80% be credited to the engines, which is not at all impossible, the consumption of steam would be only 6.93 lbs. per B. HP.-hour. A further economy can be realized if there is an exchange of heat between the exhaust steam and the feed-water to the boilers, and a gain of about 8% may thus be effected.)

This is almost exactly the same result as is given by the best gas and oil engines, and it is obtained without departing from working conditions easily realized in the present state of our mechanical knowledge.

Speaking generally, therefore, we have shown that the best results can be attained by a combination of high-pressure reciprocating engines and low-pressure turbines. This is the solution of the problem offered by M. Rateau, and it is the logical sequence of his endeavors to utilize exhaust steam.

Accumulators.—The apparatus by which the flow of exhaust steam from the primary engines is regulated, and which thus constitutes the essential and characteristic feature of the Rateau system, is the regenerate steam accumulator. Its principle is based on the use of a vessel containing metals, liquids, or any other substances intended to act as a store or flywheel of heat. In this vessel the steam accumulates and condenses; if it enters in large quantities, the temperature and pressure in the accumulator rise simultaneously. When the exhaust from the primary engine is reduced or wholly checked, steam is re-evaporated in the accumulator, because the constant drain to the turbine tends to lower the pressure, and therefore the temperature. The agent of this re-evaporation is the heat absorbed during the first period of admission of the steam by the metal or liquid conductor in the accumulator. In practice the fluctuations of temperature are generally reduced to 2 to 4° C. (= 3 to 5° F.), corresponding to a variation in the pressure of 1.6 to 2 lbs. per sq. in.

This regenerative accumulator consists of a vertical iron cylinder, in which shallow cast iron plates filled with water are arranged one above the other, the steam circulating between them. Less costly accumulators have since been introduced, and the plates replaced by scrap iron, and especially by disused iron rails. But the best system, and almost the only one now in use, is the water accumulator, comprising a horizontal boiler filled with water, through the center of which large horizontal pipes pierced with a number of holes are carried. The steam entering the pipes penetrates to the water through these openings in such a way that an active circulation is set up, and almost the entire mass of water thus becomes an agent for absorbing and refunding heat.

According to the latest published results on the consumption of steam in electrically driven winding engines, the mean expenditure of coal in electric motors, if fed with high-pressure superheated steam, is 33 lbs. per hour per B. HP. This, which represents the average for twenty-four hours, may, according to circumstances, vary from 26.5 lbs. to 39.7 lbs., and even more.

A better result can easily be obtained by compounding reciprocating engines and turbines. We take first the case of an old single-cylinder winding engine, without variable cut-off, and may put the consumption of steam in such an engine at 110 lbs. per. B. HP. hour. Taking into account the losses by condensation, which amount to about 15%, we thus get for every 110 lbs. of steam used 93.7 lbs. of exhaust steam; if this be utilized in a low-pressure turbine requiring, say, 26.5 lbs. of exhaust steam per B. HP.-hour, it will develop at least 3.5 HP. additional power. Thus the total power furnished will be 4.5 HP. for a consumption

per hour 110 lbs.; in other words, the consumption in the combined plant—reciprocating engine and turbine—will be 24.24 lbs. of steam per B. HP.-hour.

A still better result can be obtained with a modern plant—say, a good compound engine fed with superheated steam at high pressure. Taking the consumption in such an engine at 44 lbs. of steam per B. HP.-hour, and calculating as before, we see that if it be supplemented by an exhaust steam turbine requiring 26.5 lbs. of steam per B. HP., the total hourly consumption of the plant will be reduced to 16.5 lbs. per B. HP. These figures are, of course, only approximate, but they show that with the Rateau system results at least as good as those yielded by any other method can be arrived at. This may be seen in another, and perhaps still more striking way, by comparing these results for either system in a definite case. Take, for instance, an engine working intermittently, and intended to develop a mean of 500 HP., conditions which especially apply to a reversing rolling mill.

(1) If a compound engine be considered, working with high-pressure steam slightly superheated, and discharging to atmosphere, its consumption of steam under these conditions may be taken at 22,040 lbs. or 44 lbs. per B. HP.-hour (exceptionally high for a first-class compound); the same quantity, 22,040 lbs. of exhaust steam, will be available. For it must be remembered that the steam being originally superheated, there will be no perceptible condensation as it leaves the primary engine, a fact which has been verified, particularly at the Rosbach steel works. If this steam be utilized in a low-pressure turbine provided with a good condenser, it will furnish about 850 HP. additional.

(2) In an electrically-driven rolling mill an expenditure of 13,224 lbs. of steam will, according to the latest published results, be required to produce the necessary 500 HP. Taking the same working conditions as before, there will be an available surplus of 8,816 lbs., producing a maximum of 500 E. HP., if we attribute to the electric engine the very low consumption of 145 lbs. per B. HP.-hour, say 20 lbs. per kilowatt per hour. Thus, for the same expenditure of steam, additional power to the extent of 850 HP. in the one case, and 500 HP. in the other, may be obtained. This alone shows the superior efficiency in heat utilization of the Rateau system, and the important economy in cost of construction must also be noted, since electric plants for reversing engines are always very costly.

MALLEABLE CAST IRON*

By W. H. HATFIELD

Malleable cast iron consists of castings made by melting suitable pig iron and casting it into the required forms, which castings are, of course, annealed in order to produce the requisite malleability. The finished article, if successfully manufactured, possesses all the advantages of cast iron in that the low melting point of the pig iron allows the most intricate and difficult casting to be made, and these castings have the same beautiful skin and finish for which cast iron is so well known. As a further fact, it may be said that this material is practically free from blow holes, the composition of it ensuring the perfect occlusion of the gases which in a steel casting very often cause so much trouble. As regards the physical properties, it is malleable and ductile, and is easy to work in the machine shop.

All malleable cast iron when cast is identical in analysis with some variety of pig iron, it having present in its composition from 3% to 4% of combined carbon, which gives to it that intense hardness which is found in the unannealed casting. The malleablizing of the material is done either by the oxidation and elimination of the carbon or by precipitating it into such a condition that it does not militate against the production of the qualities desired.

Certain specific conditions are, of course, necessary for the production of this material when the carbon is merely changed in form, and as the irons from which the malleable castings in this country and Europe are made are generally extremely high in sulphur, not being able to change the form, manufacturers in the past have had to eliminate the carbon. Consequently the method employed is that of Réaumur, viz., packing the castings with iron

*From a paper read before the Institution of Engineers and Shipbuilders in Scotland, March 17, 1908.

ore, which oxidizes and eliminates the carbon to such an extent that the casting has attained that degree of malleability which is desired, the fracture of such casting being very similar to that of steel.

The malleable castings produced in America are of the black heart variety, and generally speaking the American process consists of precipitating the carbon and not eliminating it. These are castings which, in the finished state, have the same composition as pig iron, and which bend double and fulfil the most stringent malleable cast-iron specifications. Owing to the natural resources of America producing a pure iron with very little sulphur, the secrets of the manufacture of black heart castings were quickly learned, and it is interesting to trace the rapid growth of this industry which to-day produces from 700,000 to 1,000,000 tons of malleable castings per year.

All malleable, as previously stated, consists of cast iron of suitable composition annealed in various ways with the usual result of a malleable product. In the Réaumur process as at present conducted, the castings are of such a composition that to render them malleable it is required to eliminate to a great extent the carbon originally present. Most of the malleable castings in Europe are of this type. The castings are packed in cast-iron boxes in hematite ore, and taken to a heat at which the ore commences reaction with the carbon in the castings.

This action is the converse of the production of steel by cementation, in which process the carbon enters from the outside and gradually permeates the whole bar. In the elimination of the carbon exactly the contrary takes place, and the carbon is gradually eliminated from the outside first, so it follows that the interior of one of these castings has generally considerably more carbon than the outside. If successfully manufactured, however, the carbon in the center is in such a condition as not to militate against its working capabilities.

As to the actual chemical reaction which takes place between the iron ore and the carbon in the iron, it is not at yet sufficiently understood. However, it is known that gases easily diffuse through metals of the iron group in considerable quantities, and it is most likely that the action is somewhat dependent on the equation $CO_2 + C = 2CO$. In other words, the oxygen of the ore oxidizes the first carbon to CO_2, and this carbon dioxide possibly combines with more carbon, forming CO, which in itself receives further oxygen from the iron ore, and so what might be called catalytic action takes place in which the CO is the carrier of the oxygen from the ore to the carbon contained in the interior of the castings. Such explanation seems as likely as any other at present put forward.

The variety of malleable castings known as American black heart has for its essential distinction the fact that the castings when cast are of such a composition that the carbon, which previously exists as combined carbon, is by annealing completely changed to that condition of carbon known as annealing carbon, to which Ledebur, the German metallurgist, gave the name of temper carbon.

The author, in May, 1907, went thoroughly into this question of the change of the carbon, in a paper read before the Iron and Steel Institute, under the heading "Decomposition of Carbides." In the hard initial castings all the carbon is in the combined state, the carbon of "supersaturation" being present as carbide Fe_3C, whilst the carbon of "saturation" is present as a compound roughly equivalent to $Fe_{25}4C$. The castings are heated up during the annealing process to the temperature required (this, of course, differs with different makers), maintained for a varying period at this temperature, and are then cooled. The result is a casting in which the carbides are completely broken down into pure carbon and iron.

Reference will now be briefly made to wrought iron, which is prepared by eliminating in the plastic condition, by means of oxides, the carbon and other impurities from pig iron. The result is pure iron, with traces of sulphur, phosphorus, manganese, and a little carbon, with a varying proportion of slag, the slag being mechanically contained in the iron. Wrought iron of the best make is as pure as iron can commercially be made, and everyone is familiar with its great ductility and malleability. Apart from iron, the only content of this material worth considering is the involved slag, which, during the rolling out of the iron, is drawn into threads running the length of the bar, and gives to wrought iron that peculiar fibrous nature of the fracture. Of course, there is no such thing really as fiber in iron products, as they are all crystalline.

It is obvious that this slag is practically of no detriment to the high properties of wrought iron. Wrought-iron forgings, were it not for their high cost, are unquestionably excellent, and in working upon the subject of malleable

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cast iron, wrought-iron forging has been taken as a basis, and the endeavor has been made to produce in a malleable casting a structure as similar as possible.

The maximum stress in wrought iron is approximately 20 tons to 21 tons per square inch, and its elongation will vary from 20% to 30%. Now, if this is compared with recently published tests of malleable cast iron, viz., about 20 tons tensile strength with 1% to 6% elongation, it will be noticed that there remains considerable scope for improvement in the last-mentioned product.

Working on these lines, bars have been produced giving a tensile strength of 23 tons along with 19% elongation, 20.6% reduction of area, along with 180° bending angle. Such material which is, of course, a casting and not a forging —is, one might almost say, a new product. The old tests for malleable cast iron have been left far behind, and a material has been produced which has before it a much greater field than the original malleable cast irons.

These special castings are very similar in structure to wrought iron. Microscopically they consist of ferrite, which is pure iron, with free carbon in such a form as will be obvious by the results obtained to be little more detrimental than the slag which is found in wrought iron; in fact, samples of wrought iron have been met with which have not given much better results than the tests submitted in this paper. It will be well to conclude by asking whether malleable cast iron with the properties and tests as stated is not entitled to a much higher position in the metallurgical world than it is given? And the author would venture to suggest that the "Nomenclature" Committee gave malleable cast iron undeservedly short shrift when they stated that it merely lacked "the extreme brittleness of cast iron."

The demand for malleable in this country as compared with that of the United States gives food for thought. The Americans are said to be producing over 90% of the world's production, Europe only producing the remaining 10%. Here in this country, a material giving tests considerably superior to those obtained in the States is produced, and yet this self-same material is excluded from any purposes for which in the States it would be allowed to be used. The following table gives the comparative results which are now being obtained:

	Max. Stress, Tons per sq. in.	Elongation, %	Reduction of Area, %	Bending Angle.
Cast Iron	12	..	..	..
Old Process Malleable (Reaumur)	21	3	4	45°
American Black Heart	19	5	6	90°
Special Malleable (Meadow Hall Iron Works)	23	14	17	180°
British Admiralty Specification	18	4.5*	..	90°†

*In 3 ins. †Over a 1-in. radius.

It will be noticed that in the special malleable, maximum stress is very high, while the ductility much surpasses that of any other malleable cast iron. One obvious feature will be the ease with which this material passes Admiralty requirements.

THE DRY AIR BLAST*

By JOHN J. PORTER

The dry air blast process, the invention of which by James Gayley, vice president of the United States Steel Corporation, will probably prove to be the most important advance in the direct economy of the blast furnace of the century, while in addition it has opened our eyes to a magnificent vista of theoretical possibilities.

It has long been known that the moisture in the air blown into the furnace was a source of loss, this moisture being decomposed at the temperature of the heat into hydrogen and oxygen, with a resulting absorption of heat. This heat loss, as shown by calculation, amounts to a very small proportion of the whole and has always been considered by metallurgists as relatively unimportant, so that it remained for Mr. Gayley to actually try the experiment on the large scale.

At the Isabella furnace in Pittsburg he installed a refrigerating apparatus through which all the air pumped by the blowing engines first passed. The moisture was here deposited as frost, and the air going into the furnace contained only a very small and practically constant residue of moisture. As about four tons

*From a paper read before the Cincinnati section of the American Chemical Society, Oct. 17, 1907.

of air were required per ton of iron made, and as it was necessary to provide for a production of at least 400 tons per day, it can readily be seen that this was a large and expensive experiment, and one only possible to a person, who, like Mr. Gayley, commands the resources of a wealthy corporation.

The results obtained by this process were magnificent, and far surpassed anything which could have been reasonably expected. In place of the 5% saving in fuel which some metallurgists had calculated, a saving of 20% was made, while at the same time the output was increased about 20% and some minor economies were manifested.

These results were published by Mr. Gayley in 1904 and were explained by him as being principally due to the constancy in the amount of moisture rendering the working of the furnace more uniform and requiring the carrying of less reserve heat in the hearth. They, of course, attracted wide attention, but his explanations were by no means entirely satisfactory to the metallurgical world, and in the discussion that followed they were severely attacked. Indeed, some of our German friends even went so far as to insinuate more or less directly that the results were impossible, and that therefore must have been doctored. However, in the following year J. E. Johnson, Jr., a furnace superintendent of Longdale, Va., worked out what is undoubtedly the true explanation of the process, and at the same time propounded a new theory of the heat requirements of the blast furnace which has at one stroke placed the smelting of iron on a sound theoretical basis. This theory has since been elaborated by Prof. H. M. Howe, of Columbia University, and the net results may be said to be scarcely less important than the original invention of Gayley; since by this theory all of the means of attaining fuel economy are clearly pointed out, and furnace practice is removed from the empirical and placed on an exact basis.

This principle, which may be called the theory of critical temperatures, when reduced to its simplest terms may be stated as follows: In many heating operations there takes place at some definite temperature a heat absorbing reaction or change of state. The minimum temperature at which this can occur is termed the "critical temperature," and it is only the heat units delivered at or above this point which can be utilized.

As the clear understanding of this principle is essential in our following discussion of fuel economics, I will elaborate somewhat, and borrow a few illustrations from Prof. Howe's most lucid discussion. Continuous heating apparatus in which the heat is derived from heated gases may be divided into two classes; those which have and those which have not a critical temperature, at and above which more heat is needed than at the average of the temperatures below it. If there is no critical temperature then it suffices that there shall be some margin between that initial temperature of the heating gases and the temperature to which the objects are to be heated, and the breadth of this margin is of secondary importance. If, on the other hand, there is a critical temperature then the margin must be at least as great as called for by the proportion.

$$(T_i - T_c) : T_c :: H_c : H_b, \text{ or}$$
$$T_i = T_c \ (1 - H_c/H_b),$$

where T_c = critical temperature, T_i = initial temperature of heating gases (in most cases the temperature of combustion); H_c = heat to be supplied above the critical temperature, H_b = heat to bring the body to that temperature.

Take the case of water as an example. If it is desired only to heat it to 100° C. without boiling it then the operation belongs to the first class; the heating gases may be supplied at only the narrowest possible margin above 100° C., and yet by proper contact they may be made to give up all of their heat to the water, so that a theoretically perfect heat utilization is obtained. If, however, it is desired to boil the water the case is different. Not only must we supply 100 calories per gram to heat it up to 100° C., but we must also supply 536 calories at a temperature above 100° in order to convert the hot water into steam at the same temperature. Please note particularly that the 536 calories must be supplied at a temperature above 100°, for this is the important point, and it is quite evident that it would not avail for the purpose of boiling to supply an infinite number of calories at any lower temperature. Of course, the obtaining of this large amount of heat at a temperature above 100° C., necessitates a high initial temperature of the heating gases if we are to have efficient utilization of our heat. A concrete example will make this plain.

Suppose for simplicity that the heating gases as well as the heater have a specific heat of 1. Then if they be supplied at 101° C., the heat available for boiling will be 101 — 100, or 1 calorie per gram of gases. Wherefore it will require for boiling one gram of water, 536 grams of gases. The total heat contained in

these will be 536 × 101 or 54,136 calories, and as it only requires 100 + 536 or 636 calories to boil the water, we are only utilizing $\frac{636}{54,136}$ × 100, or 1.17% of our heat. If, on the other hand, we supply the gases at 636° C., then the heat available for boiling will be 636 — 100, or 536 calories per gram. Only one gram of gas containing 636 calories will be required, and our heat efficiency will be $\frac{636}{636}$ × 100, or 100%. In addition it is evident that at any temperature above 636 our gases can perfectly utilize their heat.

Returning to the specific case of the blast furnace, it is evident that we have here an operation involving a critical temperature, or in fact several critical temperatures, the chief of which come at the melting points of iron and slag. As these points are not so very far apart, it is sufficiently accurate for most purposes to consider only a single critical point, which is placed by Mr. Johnson at the free running temperature of the slag, or under average conditions at about 1,500° C.

Applying our previous reasoning we must have for maximum efficiency: Heat available above T_c equal to or greater than heat needed above T_c. In other words, to increase the efficiency, we can increase the heat supplied, or decrease the heat needed above the critical temperature. Now the drying of the blast acts in both ways. The heat needed is decreased because there is no moisture to be decomposed into hydrogen and oxygen, a heat absorbing reaction which only takes place at high temperatures, while in addition the temperature of combustion, T_i, and therefore necessarily the heat supplied is considerably increased.

This latter assertion I can perhaps make somewhat more clear. We have heat supplied = (T_i — T_c) × weight of gases × specific heat of gases. But

$$T_i = \frac{\text{net heat developed by reactions}}{\text{weight of gases} \times \text{specific heat of gases,}}$$

and substituting this in the first equation we have:

Heat supplied = Net heat of reactions — (T_c × weight of gases × specific heat). Now the net heat developed by the reactions is equal to the heat of combustion of the fuel less the heat absorbed by the decomposition of the moisture, wherefore the source of our saving is evident.

Finally, to summarize, the dry blast widens the margin between the temperature of combination and the critical temperature, and therefore produces an increase in efficiency measured by the increase in the heat delivered above the critical temperature, rather than by the increase in total heat supplied. The case is perfectly analogous to the fact that if gases which are to boil water be raised from 101° to 105° C., or by only 4%, the heat theoretically available for this purpose is increased by some 400%.

THE MANUFACTURE OF CONCRETE BRICK FROM BLAST-FURNACE SLAG*

By JOSIAH BUTLER, M. I. M. E.

The important question of the utilization of the waste material produced by blast and other furnaces has seriously occupied the consideration of experts for some time past, and this paper deals briefly with a method of utilizing this waste material profitably. We have first to consider the fact that all slag made by the present blast furnaces costs from 8 to 12 cts. per ton of iron produced to convey it to the slag dump, this cost not including any rental on the dumping ground. In a furnace producing 800 to 1,000 tons per week, the cost of removing the slag only would be $5,000 per annum. On account of the large amount of lime and silica contained therein, blast furnace slag is a most valuable brick making material.

Instead of removing the slag to the dump, that by running it in its molten state into water, and there granulating it, a first-class brick making material is available. The excess

*From a paper read before the Staffordshire Iron and Steel Institute, Dudley, Eng., Jan. 15, 1908.

lime in the slag causes it to granulate easily in direct contact with water, which converts all free lime into a fixed state, and at the same time eliminates all free sulphur from the slag. The ease with which the slag is granulated saves considerable expense, no grinding being necessary as with other slag and dust destructor refuse. A great number of plants are in active operation on the continent manufacturing brick from blast furnace slag.

In 1904, a small plant was erected at the Landore Works of Messrs. Baldwins, Ltd., capable of producing about 8,000 bricks per day of nine hours, as an experiment.

The brick produced by this experimental plant has proven so satisfactory as a building material that a much larger plant has been constructed at the Landore Works on the German principle, with a daily output up to 45,000 brick.

The granulating is done by running the molten slag into a bosh of water about six times the volume of the slag. The back-water from the furnace, tuyeres and coolers is used for this purpose. The excessive quantity of lime contained in the slag causes it to split up immediately upon contact with the water and all trace of unspent and free lime is entirely eliminated from the slag. The free sulphur at the same time is carried off by the great volume of steam generated in consequence of the intense heat of the molten slag falling into the water. The slag being thus granulated, is flushed down a culvert into a receiving dump at the bottom of an elevator erected at some distance from the blast furnace, which conveys it to a number of heavy squeezing rollers which separate the water from it and crushes any coarse particles of slag existing. After passing through these squeezing rolls, it drops into a hopper truck which conveys it to stock bunkers at the brick works.

For the manufacture of brick from blast-furnace slag, white lime containing no more than one-half of one per cent. of magnesia has been found to be the most satisfactory. The lime in the unslacked state is put through an ordinary jaw crusher and ground in a ball mill to pass through a mesh of about 8,000 per sq. in. The slag and unslacked lime in their proper proportions (95 to 93% granulated slag and 5 to 7% lime) are taken to the top of the building and conveyed to a silo, capable of holding enough material to make 1,000 brick. The silo when filled is dropped into a preparing machine with a steam-jacketed chamber and containing pulverizing blades working on the principle of a Root's blower. The heat generated from the steam-jacketed chamber sets up the reaction of the hot lime, which produces in the brick at this stage sufficient hardness to enable it to be handled satisfactorily by the operators of the brick press and hardening chambers. After the mixture has been thoroughly worked (about 25 minutes) and the lime sufficiently incorporated into the granulated slag, the mixture is let out on the first floor above, and there served to the machines as required. After being pressed into their requisite shapes and sizes, the brick are placed in flat-topped trolleys, holding about 700 to 900, and taken to the steaming chambers, where they are allowed to remain for 12 hours.

After the steam is turned off and blown as far as possible into the next chamber, which should by this time be ready to receive it, the brick are taken out and loaded into trucks ready for use. It is found that at this stage they are sufficiently hard to endure rough handling, the steam in the chambers having started the reaction in the lime in a very rapid manner, enabling the brick to be used on construction work as soon as they are cold enough to be handled.

Blast-furnace slag is necessarily somewhat uniform in quality, as otherwise the quality of the iron would be affected. Therefore, if the quality of the iron be right, which, of course, is the first object of the blast furnace, it necessarily follows that the resultant slag will be of a gray color and suitable for granulating. In the event of a furnace turning out black slag, it is better to remove it to the dump, rather than have varying colors in the brick.

The amount of slag required in the granulated form is about three tons per 1,000 brick. The lime employed must be, as far as possible, a pure, fat, white lime, and must necessarily contain in the slacked condition as high a percentage of oxide of calcium as it is possible to obtain. This should certainly not be under 92%. The admixture of clay or magnesia, which is supposed to impart so-called hydraulic properties to the lime, is detrimental, and any appreciable quantities of such mixtures will make the lime unworkable.

In reference to the slacking of the lime we must distinguish between two methods. 1. The slaking of lime alone without the presence of granulated or ground slag. 2. The slacking of the lime simultaneously with the mixing of the slag. In the first method many advantages which alone are offered in the latter method,

are entirely lost. One point that has an important influence on the composition of a suitable molding material, is the conversion of burnt lime into hydrate of lime, which takes place by 100 parts of burnt lime absorbing 32 parts of its weight of water, which combines chemically with the lime, generating considerable heat. The author, therefore, contends that the process in which unslacked lime is used for the purpose of mixing with granulated or ground slag, is much more suitable in all cases where the granulated slag carries a certain amount of water or moisture. The moisture, however, should not exceed 10 per cent. in the process under consideration.

The crushing strength of these brick is upwards of 2,200 lbs. per sq. in. when not less than nine months old. When thoroughly seasoned brick are immersed in water for a period of 50 hours, the increase in weight due to absorption of water is about 12.5%.

The total cost of manufacturing 1,000 brick, including interest and depreciation on a plant and building costing $50,000, and having an output of 45,000 bricks per day, is $3.13, of which $1.03 is for labor.

ELECTRIC FURNACES FOR THE IRON AND BRASS FOUNDRY

By JOHN B. C. KERSHAW

CONDENSED FROM "THE IRON TRADE REVIEW"

Electricity is undoubtedly an expensive heating agent, and at first sight proposals to employ it for producing molten metal for casting may appear to be not worth the consideration of practical men.

Taking a generating plant of the most modern type with a combined efficiency of engines and dynamos of 85% and using 3.5 lbs. of coal per kilowatt-hour generated (equivalent to 2.6 lbs. per E.HP.-hr.) we have the following comparison: Heat produced by burning 2.6 lbs. of coal, testing 14,220 B. T. U. per lb.= 36,972 B. T. U.

Heat produced by 1 HP.-hr. after conversion into electric energy, and use of this energy to produce heat by resistance heating = 2,162 B. T. U. per lb.

The ratio between the heat available in the coal burned, and that produced by the electric current when employed for resistance heating, is thus 36,972:2,162, or 17 to 1, and as already stated when studied in this manner, the proposal to employ electric methods of heating in the iron and brass factory seems to offer no practical advantage. Even should the electric energy be generated by water power, the economic advantage would seem to be on the side of the use of coke for heating purposes, say at $4.25 per ton, unless the electrical horsepower-hour could be sold to the consumer at the rate of 0.0296 cent, or $2.58 per E. HP.-year. This figure is about one-half the lowest rate yet quoted for electric energy, even in Norway and Switzerland. Unless, therefore, some very important and valuable advantages result from the use of electricity as a heating agent, its application in the iron and brass foundry is an innovation which must be long postponed. It is the purpose of the writer in this article to point out what these advantages are, and to describe some of the forms of furnace which might be employed for this special purpose.

The first and more important of these advantages is that the heat can be generated where it is required, that is, within the mass of metal requiring to be melted, and that the efficiency of the resistance type of furnace may by careful work be raised to over 75%. The losses from radiation and conduction are in fact greatly reduced as compared with the usual methods of work. How large the heat losses are in metallurgical operations as ordinarly carried on can be gaged from the following tabular statement prepared by Prof. Burgess, of the University of Wisconsin:

Product.	Type of Furnace.	Thermal Efficiency Per cent.
Cast iron	Blast	52.6
Steel	Acid process	11.9
Steel	Basic process	10.0
Pig iron	Reverberatory	8.5
Wrought iron	Reverberatory	5.0
Steel	Siemens crucible	4.0
Steel	Greenwood crucible	2.0

The blast furnace stands in a category by

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itself, and it will be many years before it is displaced. The values for the efficiency of the furnaces used for producing steel and wrought iron were calculated by comparing the heat theoretically required to raise the metal to the molten state, with that present in the fuel actually required to produce the effect in practice.

If these efficiencies be accepted as correct, the superior economy of direct heating by fuel largely disappears, for when 9/10 or 19/20 of the heat value of the fuel is lost, and only 1/10 to 1/20 is successfully utilized, the two methods of heating are practically on a level.

A second advantage offered by electric heating is that the furnaces and crucibles would have longer life than by the usual methods of work, since they would not be exposed to any external heating, and the highest temperature would be attained within the mass of metal they contained, rather than at the exterior of the furnace or crucible walls. Another advantage no less important is, that the metal during the melting operation need not be exposed to the air or to the products of combustion of the fuel used, and that therefore some of the losses due to the formation of oxides and dross would be avoided. In the melting of the finer kinds of steel, the possibility of conducting the melting operation under the surface of a protective flux or in an inert atmosphere, is of considerable value. The final advantage which will be named here, is the cleanliness with which the melting of the metal in the electric furnace is attended. In other furnaces or crucibles a certain amount of the ash of the fuel which is always present as dust in the atmosphere of the building, must get into the molten metal, and the silica, which is the main constituent of this ash, may have prejudicial effect upon the physical properties of the finished metal. With the better forms of electric heating, this contamination of the product is impossible, and the chemical constitution of the finished metal can therefore be more accurately gaged and controlled.

As a general rule one may estimate that from 400 to 500 KW.-hrs. would suffice to melt one ton of metal in resistance furnaces with internal heating, such as those of Heroult, Keller, Kjellin and Colby (See Engineering Digest, March, 1908, p. 277), and that with cheap electric power (say at $10 per E. HP.-yr.) the cost would not exceed 80 cents per ton. The writer does not suggest, however, that a large furnace for electric heating of the metal required daily in any brass or iron foundry should be erected, without preliminary trials in the laboratory or upon a small industrial scale. Each case will demand special consideration by an expert electro-metallurgist, and it is quite certain that there will be many cases in which no change can be recommended, as there would be nothing gained by substitution of electric for the ordinary methods of heating.

But in particular cases and industries, especially those relating to the production of fine castings in iron, steel or brass, electro-thermal methods have much in their favor, while the facts and figures given in preceding sections of this article prove that the electric method of working may compare favorably as regards cost, with the older process.

RECENT TESTS OF PORTLAND CEMENT AND CEMENT MORTARS

There has recently been issued by the United States Geological Survey a bulletin entitled "Portland Cement Mortars and Their Constituent Materials," which gives the results of over 25,000 tests made by Messrs. Richard L. Humphrey and William Jordan, Jr., during the years 1905-1907 at the Structural Materials Testing Laboratories at Forest Park, St. Louis, Mo. The report may be divided into two parts. The first deals with tests, chemical and physical, of the seven different cements which were donated and of a typical cement composed of a mixture of equal parts of each of the seven brands; and of tests on 1:3 mortars made with these cements in which a standard sand was used. The second part of the report deals with tests of 22 sands, 12 gravel screenings and 25 stone screenings, and of mortars made with these sands, and with the gravel and stone screenings.

The tests of the seven cements and of the mix indicate clearly that the maximum tensile strength of specimens made from neat cement is reached in about 90 days. From that time

till 180 days the tensile strength remains nearly stationary, and from 180 to 360 days there is a decrease in tensile strength of about 25%. In the case of standard mortars made from the various cements, all showed the same characteristic falling off in tensile strength from 180 to 360 days. The mix, however, showed a falling off from 90 to 180, but a slight increase in strength from 180 to 360. Further tests made on the mix, after storage in air-tight cans for periods varying from a few weeks to a year, indicated that after 180 days the tensile strength was fairly constant or slightly increased. Altogether the tests for tensile strength on both specimens made from neat cement and from standard mortars do not exhibit the uniformity which we might hope to find. As regards the falling off in tensile strength from 180 to 360 days, these tests indicate the necessity of carrying our tests over a further period of time, and also of making tests at a 270-day period. The tests on the compressive strength indicate a steady and rapid increase in strength up to 180 days and a slight increase in strength from then on. Tests on the transverse strength showed an increase up to 90 days, strength practically stationary from 90 up to 180 days, and a slight decrease from that time to 360 days.

A study of the percentage of gain in strength for various periods of time discloses the important fact that while cements may test high or low at seven days, at 360 days all are fairly close to each other. Cements which tested low at seven days, as a matter of fact, tested higher at 360 days than did those giving high strengths at 7 days.

The tests indicate, further, that mortars made with a cement composed of a mixture of a number of standard brands are likely to prove more efficient than mortars made with any of the individual brands. Further tests, however, must be made before this hypothesis can be definitely established.

The tests made on the sands, gravel and stone screenings indicate that the tensile strength of mortars made from them decreases with an increase in the percentage of voids. The same is true for the compressive and transverse tests, though not so marked in the tests for transverse strength. Tests for density of mortar indicate that the density is greatest for the least percentage of voids, as would be expected. These tests will be valuable to the contractor in that they will furnish him with a guide to the types of sand and screenings that he should avoid using in concrete work.

RECENT INCANDESCENT LAMP TESTS*

By T. H. AMRINE, B. S.†

At the present time there are only three types of incandescent lamps having a wide enough commercial use to make them important factors in incandescent lighting. The first, and by far the most widely used, is the familiar carbon filament lamp, which in ordinary sizes gives an efficiency seldom exceeding 3.1 watts per candle power with an effective life of approximately 500 hours. The second type is also a carbon filament lamp, but the carbon by the process through which it passes in manufacture is given somewhat the characteristics of a metal, and for this reason is called the metallized filament lamp. The manufacturers have claimed for it an efficiency of about 2.5 watts per mean horizontal candle power. In the third type the filament is made of the metal tantalum and there is claimed for it an efficiency of about 2 watts per candle.

From the results of tests made on ten of each of these lamps, it was found that the carbon lamp, working on steady, direct current supplied by a storage battery, at very low prices per KW.-hour ($0.01 and under) is the most economical on account of the small number of burn-outs and the low cost of the lamps. For costs of power from $0.011 to $0.032 per KW.-hour the metallized lamp gives the lowest cost, while for all higher prices of energy the tantalum gives the best economy. With alternating current even though badly fluctuating, the relative performance does not change a great deal, though on account of the large number of burn-outs with the metallized lamp

*From Bulletin No. 10, University of Illinois Engineering Experiment Station.

†First Assistant, Department of Electrical Engineering, Engineering Experiment Station.

at no time does it give the most economical results.

The investigation seems to indicate that so far as economy of operation goes, the metallized lamp has practically no field in incandescent lighting. From the standpoint of low cost of renewals, an important item with lighting companies that furnish free renewals, it cannot compete with the carbon or tantalum lamp, especially upon poorly regulated circuits and where there is vibration or rough usage. In cost of power consumption the carbon lamp leads for very low costs of power, and the tantalum for higher costs of energy. The metallized lamp seems to have a narrow field upon very well regulated circuits where the cost is between $0.02 and $0.03 per KW.-hour.

As stated above, for very low costs of power the carbon lamp gives the best economy. Hence particularly for persons who generate their own current it would not pay to change from carbon to the higher efficiency lamps, because in this case either the cost of power is low or else the fuel bill, the only item in which there would be a saving by using high-efficiency lights, is not large compared with the other expenses such as attendance charges, taxes and interest. When the cost of energy is high, as it is in most cities, the tantalum lamp would be the best to use. The metallized lamp seems to be restricted to rather narrow limits of power and cost and to good operating conditions. The newer types of lamps would have a great field in lighting railroad trains and steamships where the cost of power is always high, if filaments were robust enough to withstand the shocks and vibrations that are usually present. It seems that it might be possible and advisable for manufacturers to develop series tantalum lamps for this purpose.

The distribution of the carbon and metallized lamps is so nearly identical as to admit of little choice between them in this particular. The tantalum lamp differs from these in having a low tip candle power which is a point in its favor when used with reflectors.

Long experience in making them has enabled the manufacturers to make a carbon filament that will withstand almost any reasonable usage. The filaments of both the metallized and the tantalum lamps are easily broken, especially after they have been burned for a while. The filament of the former is so fine that jars such as would be caused by screwing the lamp into or out of the socket sometimes make the two halves of the filament cross each other near the top. This short-circuits about one-third of the filament, and if the current is turned on, the lamp then burns at about three times the normal candle power. This, of course, greatly reduces the life of the lamps if the filaments are not separated.

From the study of these lamps it appears that the carbon filament and the tantalum filament lamps can cover adequately all the phases of incandescent lighting that are now covered by the three types. For low power costs and for rough or unusual uses and for small candle power units the carbon lamp is best and often the only one that can be used. For higher costs of power upon poorly regulated circuits and for lightening the load upon overloaded stations the tantalum lamp is best. It is not recommended by its manufacturers for use upon alternating current, yet the results obtained show that although it does not do so well upon alternating current as it does upon direct current circuits, it still gives better economy for the higher power costs than the carbon lamp. The principal fault of the metallized lamp is that of mechanical weakness, which probably does not exist in the larger sizes where a heavier filament is used, so that for units of 40 or 60 candle power or above, this type of lamp is very satisfactory.

NOTES ON STEAM-TURBINE ENGINEERING*

Taking the Zoelly, Curtis, and Parsons types as representatives, it may be stated that as regards the first two an efficiency (made up of nozzle and vane efficiencies) of 70% may be attained in practice, although 65 % is more likely to be the actual figure, with a possible efficiency of some 80%. The chief losses are condensation of steam, leakage from stage to stage, disk friction, eddy currents, and vane friction. The Curtis may have a slight advantage over the Zoelly in that whenever a leakage from stage to stage does take place, the losses are collected at the end of the main stages, and the steam may be usefully expanded in the following stages. On the other hand, leakage troubles with the Curtis may become as serious as they are with the Parsons type unless there is a steam-tight joint be-

*From a paper read before the Manchester Association of Engineers by the Chief Engineer to the Manchester Corporation, Mr. S. L. Pearce.

tween the stages. With the Parsons type a possible efficiency of 83% may be reached, but in practice 65% is rarely exceeded, owing to the serious "leakage" factor. From the point of possible efficiency therefore the Parsons type stands well, but it is thought that in actual conditions there is not sufficient difference to warrant a decided opinion on the respective types.

The use of superheated steam improves both types of prime movers. In the case of a piston engine as a means of reducing initial condensation, in the case of the turbine as a means of reducing the fluid friction.

The following table brings out the difference effected in such cases:

REDUCTION OF STEAM CONSUMPTION DUE TO THE USE OF SUPERHEATED STEAM.

Superheat, degs. F...	13	30	50	100	150	200	250
Saving (%):							
Turbines	6.1	7	8	14	19	23	24.4
Piston engines..... ..	7.8	12	20.5	28	31.7	34	

The square feet of floor space per kilowatt for sets of 3,000 KW. capacity and over may be put down at 0.35 sq. ft. for piston engines, and 0.1 sq. ft. for turbines. No advantage can be shown for the steam turbine as against the piston engine for sizes of 500 KW. and under. On the other hand, given ample supplies of cooling water for capacities above this figure, and especially for the larger units of 3,000-5,000 KW., the turbine is prëeminently the prime mover to be adopted for electric work in our present state of engineering knowledge.

FUEL CONSUMPTION IN PRODUCER-GAS PLANTS*

The accompanying table (1) shows the results obtained on a wide range of fuels tested by the technologic branch of the U. S. Geological Survey, under the direction of Joseph A. Holmes, expert in charge, and Robert Heywood Fernald, engineer in charge. These tests were made at St. Louis, Mo., at the fuel testing plant, which was located on the grounds of the Louisiana Purchase Exposition.

At the time this plant was erected there were but few gas producer plants in the country burning any class of bituminous coals, and many prominent engineers were in doubt as to the possibility of operating a gas engine on gas produced from coals such as are mined in the central and western states.

This branch has done a valuable service to the country in demonstrating the possibility of burning nearly all classes of low-grade fuels with good economy. As will be noted in the tables, the poorer coals required a correspondingly greater quantity of the fuel to produce a horse-power.

The equipment used was a 250-HP. pressure producer with a centrifugal tar extractor and gas holder. A 235-HP. 3-cyl. vertical gas engine belted to a generator produced power which was measured by electric instruments connected with the switchboard. As will be seen the results obtained are much better than those from steam plants of corresponding size.

TABLE I.—FUEL CONSUMPTION IN 250-HP. PRODUCER GAS PLANT, U. S. GEOLOGICAL SURVEY.

	Cu. ft. standard gas per lb. equivalent* fuel, as fired.	B. T. U. per cu. ft. std. gas.	Lbs. fuel,* as fired per B. HP.-hr.
Florida peat.....	28.5	175.2	2.57
Lignites†.....	26.3	169.9	2.43
Illinois coals†....	49.6	153.2	1.66
Pennsylv'nia coals†	71.4	141.6	1.16
W. Virginia coals†	77.5	149.6	1.03

*Equivalent fuel includes that used in the producer, and also the amount required to generate the steam necessary for operating the producer.

†Averages of results obtained from four coals. Of the four Pennsylvania coals tested, two came from the lower Kittanning bed, one from the lower Freeport and the fourth from the Pittsburg bed. Of the West Virginia coals, one came from the Ansted bed, another from the Eagle, both of these being mined in the New River district; a third from the Pittsburg and the fourth from the Keystone bed.

TABLE II.—PROXIMATE ANALYSES AND CALORIFIC VALUES OF FUELS IN TABLE I.

Fuel.	Proximate analysis, Per cent. Moisture.	Volatile matter.	Fixed carbon.	Ash.	B. T. U. per lb. fuel, as fired.
Florida peat..	21.00	51.72	22.11	5.17	8.127
Lignites	35.05	28.96	27.72	8.27	7.104
Illinois coals..	11.51	31.81	43.46	13.22	10.651
Penna. coals..	3.47	19.68	67.31	9.54	13.651
W. Va. coals..	2.47	32.12	60.24	5.17	14.248

*Published by permission of the Director of the U. S. Geological Survey.

THE SPECIFIC HEAT OF SUPERHEATED STEAM

PROF. SIDNEY A. REEVE IN "POWER"

As to what values of S_p, after all this review (of the work of Grindley, Griessmann, Lorenz, Dodge, Linde, Knoblauch and Jakob, and Thomas) seem most worthy of acceptance, the author would state emphatically that a rough guess is all that is permissible. No single report is sufficiently beyond question to warrant loyal adoption; and the averaging of discrepant reports, each of which is open to suspicion, is hardly a scientific process.

For what it may be worth, the author would state his view of the probable truth as follows:

(1) Near the saturated condition the value of S_p (specific heat at constant pressure) increases markedly with pressure. Beginning with a value perhaps as low as 0.35 for a good vacuum, and passing 0.50 at or near atmospheric pressure, the value will pass 0.6 or 0.7 at familiar boiler pressures and possibly attain 0.8 at very high boiler pressures. There is no reason why the value should not be expected to surpass even unity at pressures beyond the highest boiler pressures, approaching the critical pressure for water.

(2) The above does not necessarily apply to conditions of superheat far removed from saturation. We should expect S_p to approach independence of the pressure, if not to independence of both temperature and pressure, under high superheat.

(3) Under constant pressure the value of S_p probably decreases with increasing temperature under the higher pressures, and increases with the temperature under lower pressures. No hazard may be made of the rate of variation with temperature, except that the rate is probably different for each different pressure, and perhaps also with the temperature itself. The rate, particularly under the higher pressures, may change sign as it proceeds; that is, being first negative and then positive, as indicated by Knoblauch and Jakob's curves (see Technical Literature, June, 1907, p. 252).

(4) Under constant temperature and varying pressure, S_p probably varies directly as the pressure.

If these estimates be true, the engineer, in order to adopt any value of S_p for use, must know not only the pressure expected, but also the range of superheat.

THE SLIPPING OF STEEL AND CAST-IRON CAR WHEELS*

By GEORGE L. FOWLER

There are two kinds of slipping to which car wheels may be subjected. One is the skidding action due to the locking of the wheels by the brake-shoes. The other form occurs when the driving wheels of electric motor cars, for instance, are turned faster than the corresponding rate of motion of the car and the whole periphery of the wheel slides over the rail.

Separate tests were made with steel and cast-iron wheels on old and new rails, for both the skidding and spinning motions. In loading the wheels, the weights were increased by regular increments of 2,000 lbs. up to 30,000 lbs.

Inasmuch as the steel wheel offers greater resistance to spinning, it is better adapted for use as the driving wheel of an electric car than the cast-iron wheel and is less liable to skidding. It appears that the cast-iron wheel wears away more rapidly than the steel wheel after the hard surface metal has been broken through.

The indications are that in skidding a short distance at low speed a cast-iron wheel is more apt to develop a flat spot than is a steel wheel. On the other hand, if the skidding continues for some distance at a high speed, the wheel becomes heated and then the steel wheel is the first to yield, unless the surface chill of the cast-iron wheel has already been worn through.

*From "The Car Wheel," published and copyrighted by the Schoen Steel Wheel Company.

COEFFICIENTS OF FRICTION BETWEEN CAR WHEELS AND RAILS.

Load on Wheel in lbs.	Spinning. Steel wheel.	Spinning. Cast-iron wheel.	Skidding. Steel wheel.	Skidding. Cast-iron wheel.
2,000	.259	.243	.285	.287
6,000	.234	.208	.245	.254
10,000	.215	.204	.238	.233
16,000	.204	.196	.232	.219
30,000	.203	.183	.234	.214

It also appears from this table that the coefficient of friction of the steel wheel decreases as the load is increased, up to a pressure of about 15,000 lbs., after which it is practically constant. The coefficient of friction of the cast-iron wheel decreases rather rapidly like that of the steel wheel, up to a load of 15,000 lbs., after which it falls away slowly, through a tendency to decrease with the increase of load is manifest.

As regards skidding, the values of the coefficients of the two wheels bear the same relation to each other as they do for spinning. The coefficient of resistance is greater for the steel wheel than for the cast-iron wheel; and there is the same falling off in the value of the coefficient as the load is increased up to about 15,000 lbs., after which that of the steel wheel is nearly constant, while that of the cast-iron wheel continues to fall away slowly.

NOTES ON ENGINEERING AND APPLIED SCIENCE FROM ALL SOURCES

Ethereal Energy.—According to Sir Oliver Lodge, in a recent lecture at the Royal Institution, the density of the ether is 50,000 million times that of platinum, and in a cubic millimeter of space there is an amount of energy represented by the output of a million-horse-power station working for 30,000,000 years.

Sterilizing Drinking Water.—The safest way of rendering water which may have been subjected to pollution innocuous for drinking is by boiling it. When it is not practicable to boil the water it can be rapidly sterilized by 4.2 grains of free bromine per gallon of water dissolved in a solution of potassium bromide, and then the excess of bromine is removed by a corresponding amount of ammonia, so as to render the water palatable. The danger of contracting enteric fever from having to drink polluted water may be avoided by adding 15 grains of sodium bisulphate to a pint of water, which is said to destroy the typhoid bacillus.—"Engineering Times."

Magnetic Alloy for Reducing Losses in Transformers, Etc.—An alloy having magnetic and electric properties especially adapting it for use in ballast coils, transformer plates, etc., and capable of reducing the magnetic and electric losses to values below those which take place with the purest iron commercially obtainable, has recently been patented by Mr. R. A. Hadfield, of Sheffield, England. This alloy may be made by melting pure Swedish or other pure iron with from 2 to 4.5% of silicon, manganese not exceeding 0.7%, and adding aluminum to an amount not exceeding 1.3%. The alloy should be low in carbon, say, under about 0.12%.

Producer-Gas Motor Car.—A Glasgow firm has been conducting experiments during the past year on a motor car using producer-gas fuel, with highly satisfactory results. The engine used was an ordinary gasoline one, with the compression increased. Tests on runs of 17 to 35 miles showed a consumption of 1 lb. Scotch anthracite pea coal per ton-mile, when the car was operated on that fuel. It was found that when producer gas was used the exhaust was entirely free from smell and invisible. The fuel hopper is placed immediately in front of the washboard, the tops of the two being at the same level. The producer is fixed to the bottom of the hopper and occupies but little space, being 14 ins. in diameter and 20 ins. high. The car with its load of a day's supply of fuel and passengers weighs about 5 tons, and can be gotten under way five minutes after the fire is lit.

Protective Action of Concrete on Steel.—Iron and steel, when embedded in concrete, are almost wholly protected from rust. This freedom from oxidation, according to Dr. Rohland, in a recent issue of "Stahl und Eisen," is probably due to physico-chemical causes which prevail during the setting process of the cement and in the early stages of hardening. The lime present in solid solution in the mass combines with water, and the colloidal aluminum oxide, together with the iron hydroxide and silica (both in the colloidal state) are separated from the mortar and are gradually coagulated by means of the hydroxyl ions. These coagulated substances act as a varnish, preventing a further penetration of the water into the interior of the cement, and thus protect the steel surfaces against the influence of the oxygen of the air and of the water.

The Metallurgy of Zinc, at the present time, is briefly comprehended in the following statements: The chief ore is zinc sulphide, Zn S, infusible at ordinary furnace heats, non-volatile, easily roasted to Zn O; the roasting is done principally in mechanically stirred furnaces, the ore being in small pieces, because it is non-porous, compact, and roasts slowly; the roasted ore, principally Zn O, is mixed with an excess of carbon as a reducing agent, and heated in closed fire-clay retorts having condensers attached; zinc vapors begin to come off at 1,033°C., and come off rapidly at the working temperature of the charge, say 1,200°

to 1,300°; the zinc vapor and carbon monoxide pass into the condensers, and as they cool deposit the zinc, some in the form of fine dust (like hoar frost), most of it as liquid drops; the cadmium in the ore and some lead, if present, distil over with the zinc, constituting its chief impurities. Arsenic is sometimes present in the condensed product. Iron does not distil over, but some is absorbed from ladles and molds in which the liquid zinc may be handled and cast.—Prof. J. W. Richards, in "Electrochemical and Metallurgical Industry."

Alcohol from Natural Gas.—Dr. Henry S. Blackmore, an industrial chemist of Washington, D. C., has devised a process of converting natural gas, which contains on an average 96% methane, into alcohol by the action of limited portions of oxygen or air in the presence of a heat-absorbing fluid, such as steam, which prevents complete combustion, and maintains the temperature below the decomposing point of alcohol, the oxidation being induced and maintained by passing the gaseous ingredients through an electrically heated gauze. By subjecting natural gas to a limited or restrained oxidation or combustion in this manner, it is converted directly into alcohols and dehydrogenated alchols known as aldehydes, the aldehyde of methyl alcohol (wood alcohol) being known as formaldehyde. The product, therefore, is a mixture of methyl alcohol with a small portion of formaldehyde, which can be readily separated. If the combustion is properly regulated and controlled, 5,000 cu. ft. of natural gas will produce approximately 50 gals. of alcohol, and as natural gas can be readily obtained in unlimited quantities at from 5 to 10 cents per M. ft., it follows that the cost of 50 gals. of alcohol produced in this manner would only be 25 to 50 cents for raw material. A plant demonstrating the commercial value of this process will shortly be erected in western Pennsylvania, probably at Bradford.—"Daily Consular and Trade Reports."

Engineering Education in Germany.—Notwithstanding the thorough treatment they give to all subjects of instruction, it is the aim of the German technical universities to turn out finished engineers who are capable of undertaking independently the execution of large engineering problems. Their aim is rather to supply the theoretical ground work essential for beginning the career of an engineer; practical experience can only be acquired outside of the technical schools after the young men are thrown wholly upon their own intellectual and moral resources. German authorities claim that the strictly theoretical character of the training given insures the best results in the end. They admit, indeed, that in the first years after quitting the lecture rooms the German engineer will not compare favorably with an English colleague who has been engaged in practical work, while the German was wresting with his theories; but that after the lapse of, say, a half dozen years these authorities claim the German will outstrip his English rival, will develop a greater originality in applying his theoretical principles, and will more easily solve new engineering problems. While the Germans cheerfully concede that English engineers have achieved remarkable results from their practical system of training, they say that—in the present stage of development of science, with its manifold and complicated new problems—the English system does not carry the engineer far enough, and that it does not give him the grasp of principles essential for making an engineer of the very highest attainments.—"Times (London) Engineering Supplement."

Comparative Costs of Illumination.—According to Mr. T. J. Little, in a paper entitled "Gas Lighting in the Factory," read before the National Commercial Gas Association, the amount of candle-power obtainable per hour for one cent from various sources of illumination can be learned from the following table:

Gas Lamps.	Cu. ft. per hr.	Candle-power.	Candle-power per hour for 1c.
Acetylene gas.....	0.5	11.6	15.5
Open tip burner.....	5.0	20.0	40.0
Gas arc, clear globe..	18.7	244.0	129.8
Upright mantle, clear chimney.....	3.7	51.27	138.5
Inverted mantle, clear chimney.....	3.0	70.6	235.33
Electric Lamps.	**Watts per hr.**		
Cooper Hewitt.....192		238.96	124.4
Enclosed arc.....600		329.05	54.84
Gem, clear bulb.....125		36.96	29.56
Nernst, clear globe, 3-glower 264		144.26	54.6
16c.-p. Edison..... 55		11.68	21.78

The above figures for candle-power are based on lower hemispherical readings; acetylene gas is assumed at $15 per M. cu. ft., illuminating gas at $1 per cu. ft., and electricity at $0.10 per kilowatt.

BOOK DEPARTMENT

METHODS AND DEVICES FOR BACTERIAL TREATMENT OF SEWAGE.—By William Mayo Venable, M. S. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. vi. + 236; 43 illustrations. $3.

Reviewed by Robert W. Hall.*

As stated in the Introduction, "Sewage Treatment," by William Mayo Venable, deals with the subject of sewage disposal purely from the engineering standpoint. The role of bacterial action is considered in the Introduction—the rest of the book being taken up with what may be termed the mechanical devices and their efficiency. As a guide to the sanitary engineer, it seems to the reviewer that this book will prove indispensable.

The second chapter deals with sewage bibliography. It is a very brief reference to books and transactions, all in English, and a list of articles published in the past two years (also confined to those in English).

The third chapter discusses the general question of the aërobic treatment of crude sewage—enumerating processes, giving data in regard to areas needed and rates of filtration. The next six chapters discuss mechanical devices. These chapters are uniform in plan, and in them the author discusses the problems to be solved, enumerates the methods and then takes up the devices from an historical standpoint, quoting significant patents in detail. The patents discussed are illustrated by figures, of which there are some forty-five, (and three plates). Many readers will be interested, as the author evidently is, in the process of evolution of the various methods, as brought out by this historical treatment. The six chapters referred to have as their subjects (IV) the mechanical removal of sludge; (V) the anaërobic treatment of sewage; (VI) intermittent contact systems; (VII) automatic discharging devices; (VIII) percolating filters.

Chapter IX is a "summary of engineering principles regarding the design of sewage purification works." Some of the twenty subjects discussed are: chemical analysis of sewage; quantity of organic matter; septic action. Under the subject of the rate of flow of water in sewage through sand, the results of personal experiments are given. Quite lengthy quotations are made from Earl B. Phelps' paper on the Analyses of Effluents, and of statements of John W. Alvord in regard to rapid sewage purification.

The tenth chapter describes in detail the actual installation of two plants—one at Fort Leavenworth, and one at Fort Des Moines. The discussion of difficulties and the methods used in meeting them should prove very helpful. In the last chapter the author suggests designs to meet typical conditions.

*Professor of Biology, Lehigh University.

THE ELEMENTS OF RAILROAD ENGINEERING.—By William G. Raymond, C. E., LL. D., M. Am. Soc. C. E., Professor of Civil Engineering and Dean of the College of Applied Science, the State University of Iowa. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. xvi. + 405; 107 figures in the text and 18 plates. $3.50.

This book is the second volume of a course in railroad engineering by Dr. Raymond, the first and third of which are in preparation and entitled "Railroad Field Geometry," and "Railroad Engineers' Field Book," respectively. The aim of the author has been to describe the fixed portion of a railroad plant and to present the underlying principles governing the design of its layout, a railroad being viewed as a plant operated for the manufacture of transportation which must be marketed at a profit to the owners. In order to cover this ground in a single volume suited to the time that can be given to the subject in a general course in civil engineering it was found necessary to treat very briefly and generally a number of topics upon which there already exist well-prepared special works, such as bridge design, for example, and to enter into greater detail on such as only considered in works of the same class. The author includes a number of original articles, among which are those on curve resistance and the cost of the worst class of rise and fall. Throughout the

book an effort is made to have the student always bear in mind that there are alternative ways of doing things from those given in the text. After an introduction, in which the economics of railroad organization are briefly outlined, Permanent Way (Part I) is taken up, chapters being devoted to such subjects as alinement, rails, rail fastenings, ties, ballast and roadbed, culverts, bridges and minor structures, turnouts, side tracks and yards, elevation of the outer rail and signaling. Part II discusses the locomotive and its work, in which the locomotive is described, its work classified and problems involving tractive effort, loads and grades are analyzed. Chapter XIV discusses expenditures and the succeeding one the effect on operating expense of change in the number of trains, the tonnage remaining constant. The effect of distance, rise and fall, and curvature on train-mile costs, and problems showing the saving due to a reduction of these factors form the subjects of the two following chapters. Part III, of five chapters, treats of reconnaissance and the preliminary survey, as well as location, construction and betterment surveys. As an appendix is given a paper, by Professor W. D. Taylor, on the location of the Knoxville, La Follette & Jellico R. R., of the Louisville and Nashville system, with the ensuing discussion, which appeared in Vol. LII of the Transactions of the American Society of Civil Engineers. While much of the contents of this paper is discussed in the text proper, the author feels that the great value of an example judiciously chosen from practice is of such effectiveness in fixing principles in the minds of students and in furnishing them with a variety of viewpoints of engineers of experience, that its inclusion is abundantly warranted.

STEAM-ELECTRIC POWER PLANTS.—A Practical Treatise on the Design of Central Light and Power Stations and their Economical Construction and Operation. By Frank Koester, Consulting and Designing Engineer, Member Verein Deutscher Ingenieure, Associate Member American Institute Electrical Engineers. New York: D. Van Nostrand Co. Cloth; 7½ × 10¼ ins.; pp. xviii. + 455; 280 illustrations, including plans, elevations and halftone plates. $5, net.

The author of this work has had an extensive experience in the design and construction of power plants ranging from 100 up to 60,000 KW. capacity, both in this country and in Europe, and has been closely identified with some of the most prominent works of this nature in the United States. He here brings together into a coherent whole the very considerable amount of information which he has accumulated during his professional work in regard to the best approved modern practice in the design, construction and operation of steam-electric power plants. Owing to the space limitation of a single volume, no attempt is made to discuss the design of boilers, turbines, generators, etc., and for the additional reason that excellent treatises on these subjects already exist. The author has been a frequent contributor to the columns of technical journals on power plant topics, and has incorporated some of his published articles, revised and extended, in the work. Chapter titles are as follows: I.—Practical Problems, Efficiency, and Costs. II.—Location, General Layout, Coal Storage and Condenser Water Supply. III.—Foundations, Buildings, Steel Construction, Architectural Features, etc. IV.—Boilers, Grates and Stokers, Coal, Combustion, Flues and Chimneys, Feed-Water Heating and Purification, Superheating. V.—High and Low-Pressure Piping. VI.—Reciprocating Engines, Turbines, Condensers, Pumping Machinery, Oiling System. VII.—Electrical Equipment. VIII.—Design of Small Power Plants. IX.—Testing Power Plants. X.—Descriptive Discussion of Typical American and European Light and Power Plants. XI.—Principal Dimensions, Data and Illustrations of Recently Constructed Light and Power Plants. In an appendix are given a number of tables of metric and English weights and measures. The work is profusely and judiciously illustrated.

HYDRAULICS.—By F. C. Lea, B. Sc., A. M. Inst. C. E., Lecturer in Applied Mechanics and Engineering Design in the City and Guilds of London Central Technical College. New York: Longmans, Green & Co. London: Edward Arnold. Cloth; 5½ × 8½ ins.; pp. xii. + 536; 367 figures and diagrams. $5, net.

In this work the author has endeavored to embody the results of the large amount of experimental hydraulic work which has been accomplished during the past decade—especially on the subject of the flow of water—and to indicate the methods used in obtaining these results. The various formulas derived by different investigators for determining the flow in pipes and channels are given, including particulars of the data from which the constants were obtained. These data are subjected to logarithmic analysis, the results of which, to-

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gether with the references cited, should prove of marked value to engineers, in enabling them to determine on the most suitable coefficients to employ under varying circumstances. Turbines receive considerable attention, the newer types being shown, drawn to scale, and an original analysis of the form of the vanes for mixed-flow and parallel-flow wheels is given. Centrifugal pumps are quite fully treated, a new characteristic equation being developed, from which the performance of the pump can be approximately determined. The work of American investigators is given prominence throughout the book, and a very considerable number of the references made are to the Transactions of the Am. Soc. C. E., including those giving details of the Cornell and Detroit experiments. Practically every important proposition is illustrated by a numerical caculation, and at the close of each chapter from ten to thirty problems are given for the further use of students. Chapters are devoted to the following subjects: Fluids at Rest; Floating Bodies; Fluids in Motion; Flow of Water through Orifices and over Weirs; Flow through Pipes; Flow in Open Channels; Gaging the Flow of Water; Impact of Water on Vanes; Water Wheels and Turbines; Centrifugal and Turbine Pumps; Reciprocating and Other Forms of Pumps; Hydraulic Machines; Resistance to the Motion of Bodies in Water (Froude's experiments); Stream Line Motion (Hele-Shaw's experiments).

CONCRETE.—By Edward Godfrey, Pittsburg: The Author. Flexible Leather; 4¾ × 6½ ins.; pp. 448; illustrated. $2.50, net.

This work may be divided into four parts. The first outlines the general principles to be followed in selecting the materials for making plain and reinforced concrete, in connection with which a thorough exposition of the properties of concrete and cement is given, together with some data on the cost of concrete structures. After this section are reprinted three articles by the author which appeared in the "Engineering News" during the year 1906, together with criticisms of these articles and the replies of the author to these criticisms. These articles deal with the design of reinforced-concrete beams and slabs, columns and footings and retaining walls. Following these articles are reprinted a number of other articles which appeared in "Concrete Engineering" in 1907, together with criticisms of these articles and the author's replies thereto. These articles deal with the design of reinforced-concrete beams, slabs, arches, chimneys, columns, domes, vaults, etc., the design of foundations, the shear of concrete and its application to the design of beams and the design of dams and the use of concrete therein. The final section of the book consists of a number of cuts reproduced from various technical journals, showing piers, culverts, small arches, etc., and illustrating current practice in their design. To those unfamiliar with Mr. Godfrey's articles on the design of beams, slabs, columns, etc., this work will prove interesting and valuable reading. The rather novel method which he uses in presenting the matter, namely, by reprinting articles of his which had previously appeared, along with the criticisms and answers to these criticisms, makes the book valuable in that both sides of these somewhat unsettled questions are brought out, thereby allowing the reader to draw his own conclusions independently of the author, and, furthermore, adds an element of interest to the reading that practically all technical works lack. Altogether Mr. Godfrey's work is a valuable contribution to the literature of concrete and concrete engineering.

THE STEAM TURBINE.—By Robert M. Neilson, Associate Member of the Institution of Mechanical Engineers; Chief of the Technical Department at the Hartlepool Works of Messrs. Richardsons, Westgarth & Co., Ltd. Fourth Edition, Revised and Enlarged. New York and London: Longmans, Green & Co. Cloth; 6 × 9 ins.; pp. xxvi. + 604; 387 figures, 46 plates and many tables. $4.20 net.

The first edition of this book appeared six years ago. Since that time a very large part of the history of the steam turbine has been made, and for the present (fourth) edition, in consequence, the text has been almost entirely rewritten, and a number of new chapters added. To do this without unduly enlarging the size, some of the older matter and an explanatory chapter on entropy-temperature diagrams have been omitted. The author's endeavor has been to treat the subject in a manner intelligible to the average engineer who is equipped with a fair, though not necessarily extensive, scientific education. The mathematical exposition of the theory involved has been rendered as simple as possible, and much attention has been given to the description of the minor details of the various types of turbines considered, which have so great an influence in determining success or failure. Contents: Fundamental Notes and Definitions;

History of the Steam Turbine; The Conversion of the Heat Energy of Steam into Kinetic Energy; Classification and Comparison of Turbine Types; Losses and Efficiencies; Vane Speeds and Bucket Efficiency; The De Laval Type of Turbine; Rateau, Zoelly and Hamilton-Holzwarth Turbines; Elektra Single-stage Turbines; Curtis, A. E. G., and Elektra (Two-stage) Turbines; The Parsons Type of Turbine; Mixed-Type Steam Turbines; Low-Pressure Steam Turbines; Effects of Steam Pressure, Superheat and Vacuum on Efficiencies; Turbo-Generators; Steam Consumption Tests; Steam Turbine Power Plants; Ship Propulsion by Steam Turbines. Appendix I gives English-metric equivalents of steam pressure, vacuum and steam consumption, and is followed by a second one in which are listed the British patents for or relating to steam turbines from 1784 up to Jan., 1906.

THE COLORADO SPRINGS LIGHTING CONTROVERSY.—A Compilation of the Records, with an Introduction and Epitome by Henry Floy, M. A. I. E. E. New York: Illuminating Engineering Publishing Co. Cloth: 6½x9½ ins.; pp. 327; illustrated. $4, net.

The controversy between the City of Colorado Springs, Colo., and the Pike's Peak Hydro-Electric Company has become memorable because it decided in a judicial way three questions of great importance to those engaged in the business of electric lighting. These questions are: First, the meaning of the phrase "An arc light of standard 2,000 candle?power; second, the monetary damage accruing by the substitution of a 6.6-ampere series alternating-current arc lamp for "an arc light of standard 2,000 candle-power"; third, the financial damage resulting from the failure to maintain the substituted lamps at their normal operating conditions. The controversy gains additional value from the fact that many of the most eminent experts of the country testified on the questions involved. The important character of the questions settled and the fact that the case was arbitrated under the statute, there being, therefore, no records of the case published in the law journals, led the author to put the facts of the case in book form. As a member of the Board of Arbitration which finally settled the matter, Mr. Floy was peculiarly fitted to undertake the work of collecting the facts and putting them into permanent shape. The author first gives a general synopsis of the controversy, and the exhibits of the plaintiff and defendant then follow. The testimony of the experts for both sides and the summing up of the attorneys is given. The award of the Board of Arbitration and a good index close the book. Altogether it is a work that will be of permanent value to electrical engineers and lawyers throughout the country.

TECHNOLOGICAL DICTIONARY.—In French, German and English, with a Large Supplement, including all Modern Terms and Expressions in Electricity, Telegraphy, Telephony, Etc. Edited by Alexander Tolhausen, Ph. D; Revised by Louis Tolhausen. Fifth Edition. New York: The Macmillan Company. Cloth; 4⅝ × 6½ ins. Vol. I (French-German-English), pp. xii. + 1006; Vol. II (English-German-French), pp. xiv. + 1026; Vol. III (German-English-French), pp. xii. + 1035. Each volume, $2.75, net.

The first edition of this valuable reference work for engineers, chemists and technologists appeared in 1877 and comprised some 75,000 words. The present (fifth) edition contains a supplement giving the equivalents of about 15,000 additional words, which the advances in recent years have made it necessary to include, particularly in electricity and chemistry. The work covers the various branches of engineering, architecture, the industrial arts, trades, manufactures, theoretical and applied chemistry, etc., and will be found to be an invaluable companion by those who find it necessary to consult technical periodicals or books printed in French and German, while the various equivalents of business and commercial terms, together with the technical definitions, make it an indispensable one to manufacturers and others having a foreign trade in countries where these languages prevail.

ENGINEERING REMINISCENCES.—Contributed to "Power" and the "American Machinist." By Charles T. Porter, Honorary Mem. Am. Soc. M. E. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6½ × 9 ins.; pp. 335; illustrated. $3 net.

To all who are interested in the history of the high-speed steam engine, this work of Mr. Porter will prove most pleasant and entertaining reading. The author, holding as he does, a most prominent position among those who helped to develop and introduce this type of engine, is one of the few living men who are in a position to write a work of this character, which not only serves to some extent as an historical record of an important period of

construction and development, but as a valuable biography as well. Among the accounts of particular interest is that of the evolution and manufacture of the first central counterpoise governor. One of the reminiscences, which reads more like a novel than an account of engineering work, is the description of the manufacture and exhibition of the first high-speed steam engine exhibited in England. A small experimental engine had run successfully in this country and a larger one was at once designed. It was shipped to England without being assembled or tested, and ran at the rate of 150 revolutions per minute, which was considered to be a remarkable speed at that time. The story of the difficulty Mr. Porter encountered in the sale of the engine, due to the fact that it was a non-condensing engine, holds one's attention throughout. The work is written in a simple but interesting style and its perusal will doubtless give many an engineer several pleasant hours.

ELEVATOR SERVICE.—By Reginald Pelham Bolton, Member of the American Society of Mechanical Engineers; Author of "Motive Powers and Their Practical Selection." Published by the Author, at 527 Fifth Ave., New York. Cloth; 7¾ × 10¾ ins.; pp. viii. + 69; 11 figures and diagrams, including 2 folding plates. $5, net.

In this book the author shows the share in the work of the elevator which is actually contributed by the public using it, and by the analysis of a considerable amount of personally collected data he establishes a duty or rating for elevators, the speed and number of floors served being given. The method of calculating the desirable combination of elevators and building is thus brought out, and some interesting comparisons are made as to the tenancy of various classes of buildings, which should prove of great value to those who contemplate the erection of similar structures. The subject of express service is dealt with, as also is that of the equal division of traffic to the upper and lower portions of high buildings. Much valuable and hitherto unavailable information in regard to the sizes of elevator cars is given, together with the proportionate loads which accompany their use in serving certain numbers of floors. Chapters are included under the following titles: Vertical Transportation; Operating Conditions; Passengers and Operators; Rating the Work of the Elevator; Computing the Average Work; Express Service; The Shape and Size of the Car; Load and Speed Combinations; The Building and Its Proportionate Service; Relation of Elevators to Area, Occupants and Floors. A large folding diagram is given, by means of which the number of elevators for various numbers of floors can be readily found for buildings of varying areas and for different conditions of tenancy, and by which the elevator service of existing buildings can be accurately compared with others. An interesting and useful glossary of terms used in connection with elevators is also included.

THE ELECTRIC FURNACE.—Its Evolution, Theory and Practice. By Alfred Stansfield, Professor of Metallurgy in McGill University, Montreal. Toronto: The Canadian Engineer. New York and London: The Hill Publishing Co. Cloth; 6 × 9 ins.; pp. 211; 53 text illustrations. $2.

The rapid development of the electric furnace and the many improvements which have been made in it in the last few years have made it extremely difficult for the metallurgist to keep himself informed of these advances. Five years ago the electric furnace was little more than a scientific curiosity; to-day it is looming up as a rival to both the Bessemer converter and the open hearth furnace. The advances and improvements in the methods of construction and operation of the electric furnace are here treated by Professor Stansfield in a simple and interesting style. The book consists of a series of papers, written about a year ago, for the "Canadian Engineer" and now collected by the author into one volume. The opening chapter of the book presents a concise account of the history of the electric furnace. Chapter II is devoted to the description and classification of the various types of furnaces. In Chapter III the question of the efficiency of the electric furnace and the relative cost of electrical and fuel heat. Chapter IV takes up in detail the design, construction and operation of the electric furnace. The next two chapters treat of the production of iron and steel in the electric furnace and its other uses, such as the production of zinc, carborundum, alundum, etc. The work closes with a short chapter on the future of the electric furnace, the author giving his views as to the possibilities of its development. Professor Stansfield's work will be found valuable by metallurgists as being a complete and thorough compendium of present day knowledge on the subject of the electric furnace. Its value is enhanced by frequent references to articles in recent technical publications and to papers presented before various scientific societies.

NEW BOOKS.

Civil Engineering.

METHODS FOR EARTHWORK COMPUTATIONS.—By C. W. Crockett, Professor of Mathematics and Astronomy, Rensselaer Polytechnic Institute. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. x + 114; 90 figures. $1.50, net.

SECONDARY STRESSES IN BRIDGE TRUSSES.—By C. R. Grimm, C. E., M. Am. Soc. C. E., etc. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. viii + 140; 60 illustrations and 13 numerical examples. $2.50.

Economics.

CORPORATE FINANCE AND ACCOUNTING.—Treating of the Corporate Finances and Securities; the Corporate Books of Account; Reports; Negotiable Instruments; and the Powers, Duties and Relations of the Corporation Treasurer. With Forms. By Harry C. Bentley, C. P. A. Legal Notes by Thomas Conyngton, of the New York Bar. New York: The Ronald Press. Cloth; 6 × 9½ ins.; pp. 525. $4.

Geology.

A KEY FOR THE DETERMINATION OF ROCK-FORMING MINERALS IN THIN SECTIONS.—By Albert Johannsen, Ph. D., Member U. S. Geological Survey. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; large 8vo; pp. ix + 542; 131 figures and diagrams and 1 colored plate. $4.

Materials.

DIE PRUEFUNG UND DIE EIGENSCHAFTEN DER KALKSANDSTEINE.—Results of Tests Made in the Royal Testing Institution at Gross-Lichterfelde West. By H. Burchartz. Berlin, Germany: Julius Springer. Paper; 7¾ × 11 ins.; pp. 105; 13 illustrations, mostly in the text. 5 marks; American price, $2.

WOOD.—A Manual of the Natural History and Industrial Applications of the Timbers of Commerce. By G. S. Boulger, Honorary Professor of Natural History in the Royal Agricultural College. Author of "Familiar Trees," etc. Second Edition, revised and enlarged. London, Eng.: Edward Arnold. New York: Longmans, Green & Co. Cloth; 5¼ × 8¾ ins.; pp. 348; 48 plates and 43 text illustrations. $4.20 net.

Mechanical Engineering.

BAU RATIONELLER FRANCISTURBINEN-LAUFRAEDER.—Und deren Schaufelformen für Schnell, Normal—und Langsam-Läufer. By Viktor Kaplan. Munich and Berlin, Germany: R. Oldenbourg. Cloth; 5½ × 8¾ ins.; pp. 346; illustrations in the text and 7 plates. 9 marks; American price, $3.60.

DEVELOPMENT AND ELECTRICAL DISTRIBUTION OF WATER POWER.—By Lamar Lyndon. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¾ × 9¼ ins.; pp. 317; 158 illustrations in the text. $3, net; English price, 12s. 6d., net.

HIGH STEAM-PRESSURES IN LOCOMOTIVE SERVICE.—By William F. M. Goss, Dean of the College of Engineering, University of Illinois, Urbana. Washington, D. C.: The Carnegie Institution of Washington. Cloth; 6¾ × 10 ins.; pp. 144; 120 illustrations, mostly in the text, and numerous diagrams and tables. $1.25.

HYDRAULIC ENGINEERING.—A Treatise on the Properties, Power and Resources of Water for All Purposes. By Gardner D. Hiscox, M. E., Author of "Mechanical Movements," etc. New York: The Norman W. Henley Publishing Co. Cloth; 6 × 9¼ ins.; pp. 315; 305 illustrations, partly in the text, and 36 tables. $4.

MACHINE-SHOP TOOLS AND METHODS.—By W. S. Leonard, formerly Instructor in Machine-Shop Practice and in Practical Machine Design, Michigan Agricultural College. Fifth Edition, revised and enlarged. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. ix + 571; 702 figures in the text. $4.

MASSENTRANSPORT. — A Text-Book on Transportation and Storage of Bulk Materials. By M. Buhle, Professor of Machine Design, Hoisting and Conveying Machinery, at the Royal Technical College, Dresden, Stuttgart and Leipzig, Germany; Deutsche Verlags-Anstalt. Paper; 7½ × 11 ins.; pp. 382; 856 illustrations in the text, and 80 tables. 20 marks; bound, 22 marks; American price, $8.

Metallurgy.

LEAD REFINING BY ELECTROLYSIS.—By Anson Gardner Betts. New York: John Wiley & Son. London: Chapman & Hall, Ltd. Cloth; 6 × 9 ins.; pp. ix + 394; 74 figures and 16 full-page half-tone plates. $4.

THE BLAST FURNACE AND THE MANUFACTURE OF PIG IRON.—An Elementary Treatise for the Use of the Metallurgical Student and the Furnaceman. By Robert Forsythe. New York: David Williams Co. Cloth; 6 × 9½ ins.; pp. 368; text illustrations, $3, net.

WASHING AND COKING TESTS OF COAL AND CUPOLA TESTS OF COKE.—Conducted by the United States Fuel-Testing Plant at St. Louis, Mo., Jan. 1, 1905, to June 30, 1907. By Richard Moldenke, A. W. Belden and G. R. Delamater. With Introduction by J. A. Holmes, in Charge of Technologic Branch. Bulletin No. 336, U. S. Geological Survey, Washington, D. C. Paper; 5¾ × 9 ins.; pp. 76.

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DIGITAL PAPERS

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ECONOMICAL STREET CLEANING.

The problem of cleaning paved streets quickly and efficiently at a low cost is one which has perplexed municipal officials for many years. In many places the work is done by "white wings," who receive from $1 to $1.75 per day and who cover but a small area. The large sweepers, which are horse-drawn, are expensive in their first cost, require 1 to 2 horses per sweeper, besides the driver, and also raise a great deal of dust, which is objectionable to persons using the street while sweeping is going on. An easily operated hand sweeping machine has recently been placed on the market, at a low cost, which does the work of about three men; as it requires but one man to operate it, a decided saving is effected, great enough, in fact, to pay for itself in from one to two months. This hand sweeper, which is known as the "Peerless," is sold by James S. Barron, 129 Franklin St., New York City. An important advantage of the "Peerless" machine is that it will pick up the finest dust, which horse sweepers or "white wings" either leave behind or throw into the air.

The "Peerless" machine is rapidly being adopted by the street cleaning departments of many cities throughout the United States and Canada. A recent report of the Superintendent of the Street Cleaning Department of Washington, D. C., states that in the first year the machines were installed a saving of $15,000 was effected, and the superintendent stated in his report that a considerably larger sum would be saved the following year, as the machines had been rented for a considerable period of time before being purchased. Cost data showing the saving effected by the use of the "Peerless" sweeper by many other cities, and by corporations using it for cleaning large floor spaces, etc., may be had on application to the agent.

The machine is not only adapted for cleaning streets, but can be used for sweeping warehouses, platforms, and other large unobstructed floor spaces. It was the only hand sweeper used at the St. Louis Exposition in 1904, and was also used for sweeping the streets and cleaning the floors of the large exhibition buildings of the Centennial Exposition at Portland, Ore., in 1905.

IMPROVED FORM OF MILL FLOOR.

In the design of the new jute mill of the Columbian Rope Co., at Auburn, N. Y., the architect, Mr. Charles T. Main, of Boston, has introduced somewhat unusual features in the design of the floors. Because of the large size and excessive weight of the machines in the second and third stories, as well as on account of vibratory effect of their rotary movement, exceptional strength and stability was required. The columns, spaced on 10-ft. bays across the building and on 18 to 24 ft. centers lengthwise, are of 16x16-in. Georgia pine. The beams running lengthwise of the mill are of the same size and material, while the flooring is of 6-in. plank, spliced and toe nailed together, and covered with ordinary maple top. The result is a practically solid floor which is absolutely rigid and capable of sustaining the heaviest possible loads.

A REINFORCED-CONCRETE FACTORY WITH 50-FT. SPANS.

There has been recently completed at 331 West 15th St., New York City, a 5-story reinforced-concrete factory building which presents some unique and interesting features. The owner of the building is a soda-water manufacturer and to meet his requirements it was necessary to design a building which would allow teams to drive all over the first floor. To do this 50-ft. spans were necessary. The building was designed by Mr. Howard Chapman, Architect, the engineering details worked out and the construction carried on by the Turner Construction Co., 11 Broadway, New York City.

Test borings showed that water would not be encountered at the depth required for the foundations. The sandy soil required careful shoring of all the neighboring houses. The underpinning was carried to the same depth as the footings of the new building. The remainder of the lot had sheet piling as was required by the local character of the sand. The depth of the basement floor below the street level made the taking care of the bank pressure a special problem. It was met by a battered and buttressed wall, heavily reinforced.

The building is 50x150 ft., with a 50x65 ft. "L." The main part of the building has no interior columns, the 50-ft. beams resting on the walls direct. These walls along the west side of the building are 150 ft. long and on the east side 90 ft., the beams resting on pilasters, in the walls, 2 ft. thick. The cross-section of the beams varies, but in general the beams for the "L" part of the building are 7 ins. wide and 12 ins. deep below the bottom of the 4-in. slab and are spaced 5 ft., center to center. The

FIG. 1. RICHARD BRIDGE-STRAIN RECORDER.

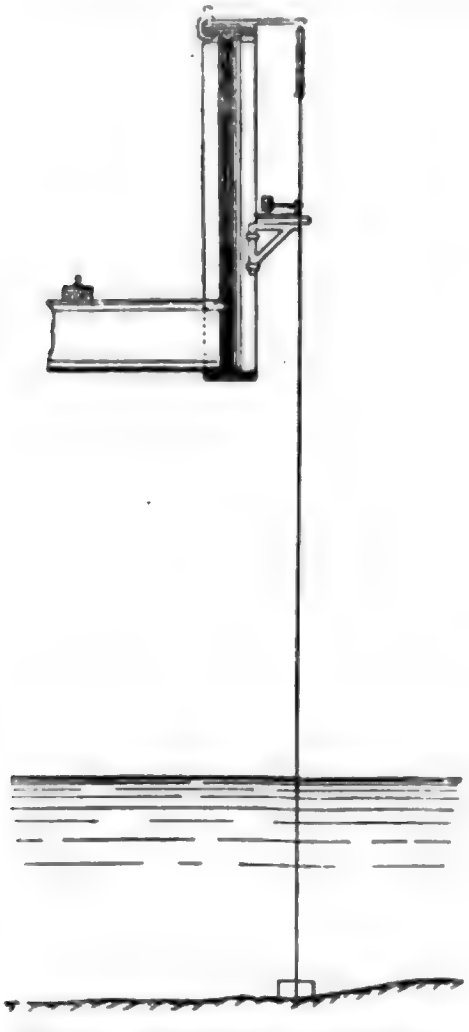

FIG. 2. RECORDER IN POSITION.

ment is preferably placed in the roadway. When a vertical deflection is to be recorded the lower end of the wire is anchored to the earth and to the upper end of the roadway itself; the recording being obtained by a relative movement, the wire playing the part of a fixed rod, as indicated in Fig. 2. For measuring a horizontal deflection a fixed point is established at the level of the roadway, the wire being attached to a spiral spring in connection with the upper level of the roadway, and two anchorages in the earth. The fixed point thus serves to operate the recording instrument. By means of other arrangements, direct records of deflections or displacements, measured not from the earth or the anchorage, but relative to the structure itself, can be obtained, as, for example, the deflection of the center of a beam referred to its supports.

The wide range of application of this instrument, together with the value of the records which may be obtained by its use, makes it indispensable in the testing of bridges and similar structures. The single fact that the deflection of a bridge is generally regarded as the factor which decides the length of its life, shows the value of an instrument of this character. This deflection recorder is manufactured by Jules Richard, of Paris, France, and is sold in this country by Ernest Du Vivier, 14 Church St., New York.

FOR THE FILE.

Catalogs and literature of machinery, tools and supplies used by engineers, contractors, etc., should always be on hand for reference. When writing the manufacturer or dealer whose catalogs have been reviewed or advertised in the Engineering Digest, please state that you saw the same mentioned in this magazine.

THE FARNHAM BLUE BOOK.—National Waterproofing and Cleaning Co., 1 Madison Ave., New York. Paper; 3½ × 6 ins.; 16 pages.

This booklet describes the method of waterproofing structures employed by the National Waterproofing and Cleaning Co., which controls the Farnham patents. The method, briefly, consists in the use of pure wax either on the surface or in the body of the structure. The prepared wax is either painted on the surface, thereby effectually closing up the pores, added in the form of a powder to the cement, or applied to the surface under the influence of heat. The company's preparations are applicable, not only to concrete structures, but to marble, limestone, native rubble stone and brick structures, as well.

FOREST MANAGEMENT.—F. R. Meier, Consulting Forester, 1 Broadway, New York City. Paper; 5 × 6 ins.; 8 pages.

In this booklet Mr. Meier discusses briefly the management, preservation and improvement of forest estates, timber tracts, woodlands, game preserves, lands of water supplies, timber estimating, combating of insect pests and diseases of trees, etc. Mr. Meier was trained in the home of forestry—Germany—and after several years of practical experience in that country came to the United States, where for 16 years he has been engaged in work along the line of his profession, at the present time in the capacity of consulting forester.

MECHANICAL WATER FILTERS.—The New York Continental Jewell Filtration Co., 15 Broad St., New York. Paper; 9 × 6 ins.; 48 pages; illustrated.

The New York Continental Jewell Filtration Co., which controls a majority of the patents for various types of mechanical filters for the purification of public and private water supplies, in this catalog give the standard sizes of the various types of filters which they manufacture together with a short summary of the advantages and uses of each particular type A number of tables are also given, which show the efficiency of various filtration plants installed by the company, as indicated by tests covering a considerable period of time.

WATERWORKS SPECIALTIES.—The Waterworks Equipment Co., 180 Broadway, New York. Paper; 9 × 6 ins.; 48 pages; illustrated.

This catalog illustrates and describes : number of machines and appliances manufactured by the Waterworks Equipment Co. Among these are several tapping machines, some of which are equipped with gasoline motors, this company holding the exclusive right to manufacture tapping machines equipped in this manner. Among other articles illustrated are emergency sleeves, corporation stop cocks, pipe jointers, thawing machines, pumping outfits, etc. Two substitutes for lead, lead wool and leadite are also described and their applications illustrated. A number of interesting testimonials are also given.

FORMS AND CENTERING FOR CONCRETE WORK.—The Duralite Co., 42 Broadway, New York City. Paper; 6 × 9 ins.; 12 pages; illustrated.

This circular describes the sheet—and corrugated-metal forms manufactured by this company for use on all classes of concrete construction. These forms weigh only about one-half as much per surface foot as ordinary forms, and have unusual strength and rigidity. They are rented on a basis that gives a contractor the use of three stories or sets of forms for very little more rental than one set, and at no greater expense than the building of one story with a set of wooden forms, thus saving in first cost and hastening the time of completion of the work. Curved forms for sewer and invert work in brick and concrete are also described and illustrated.

THE HENNIBIQUE ARMORED CONCRETE SYSTEM.—Hennibique Construction Co., 1170 Broadway, New York. Paper; 8 × 11 ins.; 98 pages; illustrated.

This catalog describes the Hennibique system of reinforced-concrete construction, according to which more than twenty-two thousand buildings, at a cost of more than $100,000,000, have been constructed. Francois Hennibique, the inventor and patentee, after a number of years of study and tests, devised his system, in which the reinforcement of the beams is formed by steel bars placed at the lower flange, where the tensile stresses occur, and by vertically placing stirrups embracing the steel tension bars, and intended to take the vertical and horizontal shear developed in the beams. The system is described in full detail in this catalog and many illustrations are given showing its wide range of application to engineering construction in general.

IRON AND WIRE FENCES, RAILINGS, GATES, ETC.—Anchor Post Iron Works, 41 Park Row, New York City. Catalog No. 35. Paper; 8¼ × 5½ ins.; 24 pages; illustrated.

This catalog describes and illustrates a few of the large line of wire fences made by this company, together with a number of examples of wrought-iron railings and gates. A metallic post used in connection with the fencing manufactured by this company consists of a U-shaped bar of high-carbon steel, the shape of section and quality of steel doubly providing for strength and stiffness. This post is anchored simply, but effectively, after being driven into the ground, by having two blades or stakes driven into the ground at opposite angles through a socket fastened to the base of the post. No digging is required, and the posts are held firmly by the angle-iron blades and always maintain their true alinement. The posts are galvanized and their durability has been well tested through the ten years they have been manufactured. A new product of the company is a chain-link wire fence netting made made of No. 6 wire with meshes 2¼ ins. square. This is claimed to be the strongest and best fencing fabric to be had.

THE
TECHNICAL PRESS INDEX

220 BROADWAY, NEW YORK

This Index is intended to cover the field of technical literature in a manner that will make it of the greatest use to the greatest number—that is, it will endeavor to list all the articles and comment of technical value appearing in current periodicals. Its arrangement has been made with the view to its adaptability for a card-index, which engineers, architects and other technical men are gradually coming to consider as an indispensable adjunct of their offices.

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The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

In order to comply with the many suggestions and requests of readers who desire to make practical use of this index, it is printed on one side of the sheet only, to permit the clipping of any desired items.

LIST OF PERIODICALS INDEXED

JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

Journal Am. Foundrymen's Assn.
Journal Assoc. Engineering Societies.
Journal Eng. Soc. of Western Pa.
Journal Franklin Institute.
Journal West. Society of Engineers.
Proceedings Am. Soc. C. E.
Proceedings Am. Soc. M. E.
Proceedings Can. Soc. C. E.
Proceedings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
Proceedings Pacific Coast Ry. Club.
Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
Transactions Am. Inst. Electrical Engineers.
Transactions Am. Inst. Mining Engineers.

(*Continued on second page following.*)

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An inch card under this heading costs $2.50 a mon n

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A Journal of the Iron, Steel, Metal, Machinery and Hardware Trades.

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Mining Science

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Treats of Gas and its application to domestic and industrial operations. Subscription $3. Specimen copy, 15 cents.

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The Railway Age

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AMERICAN AND CANADIAN PERIODICALS

Acetylene Journal.
American Architect and Building News.
American Artisan.
American Builders' Review.—See Adv. opposite.
American Carpenter & Builder.
American Engineer and R. R. Journal.
American Exporter.
American Gas Light Journal.
American Industries.
American Inventor.
American Journal of Science.
American Machinist.
American Shipbuilder.
Architect & Engineer of California.
Architectural Art.
Architectural Record.
Architectural Review.
Architects' and Builders' Mag.
Architecture.
Automobile.
Boiler Maker.
Brass World.
Brick.
Bulletin Am. Iron & Steel Assn.
Bulletin of Dept. of Labor.
Bulletin Univ. of Kansas.
Bulletin Univ. of Wisconsin.
California Journal of Technology.
Canadian Architect and Builder.
Canadian Cement & Concrete Review.
Canadian Electrical News.
Canadian Engineer.
Canadian Machinery & Manufacturing News.
Canadian Manufacturer.
Canadian Mining Journal.
Canadian Municipal Journal.—See Adv. opposite.
Carpentry and Building.
Cassier's Magazine.
Castings.
Cement.
Cement Age.
Cement and Engineering News.
Cement Era.
Central Station.
Chemical Engineer.
Cold Storage and Ice Trade Journal.
Commercial America.
Compressed Air.—See Adv. opposite.
Concrete.
Concrete Age.
Concrete Engineering.
Contractor.
Cornell Civil Engineer.
Daily Consular and Trade Reports.
Domestic Engineering.
Economic Geology.
Electrical Age.
Electrical Review.
Electric Journal.
Electric Railway Review.—See Adv. opposite.
Electrical World.
Electric Traction Weekly.
Electrochemical and Metallurgical Industry.
Engineering-Contracting.—See Adv. opposite.
Engineering and Mining Journal.
Engineering Magazine.
Engineering News.—See Adv. opposite.
Engineering Record.
Factory.
Far Eastern Review.
Fire and Water Engineering.
Forestry and Irrigation.
Foundry.
Gas Engine.
Gas Power.
Glass and Pottery World.
Hardware.
Heating and Ventilating Magazine.
Horseless Age.
Ice and Refrigeration.
Illuminating Engineer.
Implement Age.
Industrial Magazine.—See Adv. opposite.
Industrial World.
Inland Architect.
Insurance Engineering.
International Marine Engineering.
Iron Age.—See Adv. opposite.
Iron Trade Review.
Irrigation Age.
Journal of Electricity, Power and Gas.
Journal of U. S. Artillery.
Journal of Worcester Polytechnic Institute
Machinery.
Marine Review.
Metal Industry.
Metal Worker, Plumber and Steam Fitter.
Mines and Minerals.
Mines and Mining.
Mining and Scientific Press.
Mining Science.
Mining World.
Modern Machinery.
Moody's Magazine.
Motor.
Motor Age.
Motor Boat.
Motor Car.
Municipal Engineering.
Municipal Journal and Engineer.
Paper Trade Journal.
Plumber's Trade Journal.
Popular Mechanics.
Popular Science Monthly.
Power and The Engineer.
Power and Transmission.
Power Wagon.
Printers' Ink.
Profitable Advertising.
Progressive Age.—See Adv. opposite.
Railroad Gazette.
Railway Age.—See Adv. opposite.
Railway and Engineering Review.
Railway and Locomotive Engineering.
Railway and Marine World.
Railway Engineering.
Railway Master Mechanic.
Roadmaster and Foreman.—See Adv. opposite.
Rock Products.
Rose Technic.
Scientific American.
Scientific American Supplement.
Selling Magazine.
Sibley Journal of Engineering.
Southern Machinery.
Stevens Institute Indicator.
Stone.
Street Railway Journal.

Technical World Magazine.
Technology Quarterly.
Textile Manufacturer's Journal.
Tradesman.
Waterproofing and Fireproofing.
Western Electrician.
Wood Craft.
Wood Worker.

PRINCIPAL BRITISH PERIODICALS

Agricultural Chronicle. (m.) London.
Architect. (w.) London.
Architects' Magazine. (m.) London.
Architectural Review. (m.) London.
Autocar. (m.) London.
Automobile Journal. (m.) London.
Automotor Journal. (w.) London.
Board of Trade Journal. (w.) London.
British Architect. (m.) London.
British Clay Worker. (m.) London.
British Trade Review. (m.) London.
Builder. (w.) London.
Building Industries. (w.) Glasgow.
Civil Engineering. (w.) London.
Cold Storage. (m.) London.
Colliery Guardian. (w.) London.
Commercial Motor. (w.) London.
Concrete & Constr. Engg. (b-m.) London.
Contract Journal. (w.) London.
Electrical Engineer. (w.) London.
Electrical Engineering. (w.) London.
Electrical Magazine. (m.) London.
Electrical Progress. (m.) London.
Electrical Review. (w.) London.
Electrician. (w.) London.
Electricity. (w.) London.
Engineer. (w.) London.
Engineering. (w.) London.
Engineering Review. (m.) London.
Engineering Times. (w.) London.
Engineering World. (w.) London.
Engineers' Gazette. (m.) London.
English Mechanic. (w.) London.
Gas and Oil Power. (m.) London.
Gas Engineers' Magazine. (m.) London.
Hardware Magazine. (m.) London.
Implement and Machinery Rev. (m.) London.
Iron and Coal Trades Review. (w.) London.
Iron and Steel Trades Journal. (w.) London.
Ironmonger. (w.) London.
Ironmongers' Chronicle. (w.) London.
Journal of Gas Lighting. (w.) London.
Journal of Society of Arts. (w.) London.
Locomotive Magazine. (m.) London.
Marine Engineer. (m.) London.
Mariner. (m.) London.
Mechanical Engineer. (w.) Manchester.
Mechanical World. (w.) Manchester.
Mining Engineering. (m.) London.
Mining Journal. (w.) London.
Mining World. (w.) London.
Motor. (w.) London.
Motor Boat. (w.) London.
Motor Car Journal. (w.) London.
Motoring Illustrated. (m.) London.
Municipal Journal. (w.) London.
Nature. (w.) London.
Oil Trades Gazette. (m.) London.
Page's Weekly. (w.) London.
Paper Maker. (m.) London.
Paper Making. (m.) London.
Petroleum World. (m.) London.
Practical Engineer. (w.) London.
Public Works. (q.) London.
Quarry. (m.) London.
Railway Engineer. (m.) London.
Railway Gazette. (w.) London.
Railway Magazine. (m.) London.
Railway Times. (w.) London.
Science Abstracts. (m.) London.
Sells' Commercial Advertiser. (w.) London.
Surveyor. (w.) London.
Textile Journal. (m.) London.
Timber Trades Journal. (m.) London.
Times Engineering Supplement. (w.) London.
Tramway and Railway World. (m.) London.
Water. (m.) London.

PRINCIPAL FRENCH, GERMAN AND OTHER FOREIGN PERIODICALS

Annales des Ponts et Chaussées. (m.) Paris.
Beton und Eisen. (q.) Vienna.
Betonzeitung. (s-m.) Halle a/S.
Cemento. (m.) Milan.
Comptes Rendus de l'Acad. des Sciences. (w.) Paris.
Deutsche Bauzeitung. (b-w.) Berlin.
Dingler's Polytechnic Journal. (w.) Berlin.
Eisenbahntechnische Zeitschr. (b-m.) Berlin.
Electricien. (w.) Paris.
Elektrische Kraftbetriebe und Bahnen. (w.) Berlin.
Elektrochemische Zeitschrift. (m.) Berlin.
Elektrotechnik und Maschinenbau. (w.) Vienna.
Elektrotechnische Zeitschrift. (w.) Berlin.
Elettricità. (w.) Milan.
Génie Civil. (w.) Paris.
Gesundheits-Ingenieur. (s-m.) Munich.
Industrie Electrique. (s-m.) Paris.
Ingenieria. (s-m.) Buenos Aires.
Ingenieur. (w.) Hague.
Journal f. Gasbeleuchtung. (w.) Berlin.
Métallurgie. (w.) Paris.
Minero Mexicano. (w.) Mexico.
Mois Scientifique. (m.) Paris.
Organ f. d. Fortschritte des Eisenbahnwesens. (m.) Wiesbaden.
Revista d. Obras Pub. (w.) Madrid.
Revista Tech. Indus. (m.) Barcelona.
Revue de Mécanique. (m.) Paris.
Revue Gén. des Chemins de Fer. (m.) Paris.
Revue Gén. des Sciences. (w.) Paris.
Revue Industrielle. (w.) Paris
Revue Technique. (b-m.) Paris.
Revista Marittima. (m.) Rome.
Schiffbau. (s-m.) Berlin.
Schweizerische Bauzeitung. (w.) Zurich.
Stahl und Eisen. (w.) Düsseldorf.
Technique Sanitaire. (m.) Paris.
Zeitschrift für Bauwesen. (q.) Berlin.
Zeitschrift f. d. Gesamte Turbinenwesen. (w.) Munich.
Zeitschrift d. Oest. Ing. und Arch. Ver. (w.) Vienna.
Zeitschrift d. Ver Deutscher Ing. (w.) Berlin.
Zeitschrift für Elektrochemie. (w.) Halle a/S.
Zentralblatt d. Bauverwaltung. (s-w.) Berlin.

Index to Articles begins on Second Page Following.

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INDEX TO ARTICLES

ARCHITECTURE.

For Steel and Reinforced Concrete Building Construction, Foundations, Masonry, etc., see "Engineering Construction and Materials" under CIVIL ENGINEERING; for Heating and Ventilation, see subdivision similarly entitled under MECHANICAL ENGINEERING; for Electric Lighting, see "Lighting" under ELECTRICAL ENGINEERING; for Elevators, see "Hoisting and Handling Machinery" under MECHANICAL ENGINEERING; for Plumbing and Sanitation, see "Sewerage" under MUNICIPAL ENGINEERING.

The Influence of the Ecole des Beaux-Arts on Our Architectural Education. Prof. A. D. F. Hamlin. Arch Rec—Apr., 08. 3800 w. 40c.

The University of California. Arch Rec—Apr., 08. 20 figs. 7000 w. 40c.

AUTOMOBILES AND AERIAL NAVIGATION

Aeroplane.

The First Successful Trial of a New American Aeroplane. Sc Am—Mar. 21, 08. 3 figs. 1700 w. 20c. Describes test on Lake Keuka, N. Y., of an aeroplane which succeeded in lifting 20 lbs. weight per HP. and which had 1.48 sq. ft. of supporting surface per lb. weight.

Heavy Motor Vehicles.

Petrol-Electric Systems for Heavy Vehicles. P. Frost Smith and W. A. Stevens. Elec Engg—Mar. 26, 08. 2 figs. 2800 w. 40c. Paper read before the Society of Road Traction Engineers.

Motor-Car Design.

Apparatus for the Study of Auto Suspension. Automobile—Mar. 19, 08. 2 figs. 1100 w. 20c. Translation from "La Technique Automobile," by C. B. Hayward.

Castellated Shafts. Engg—Mar. 13, 08. 5 figs. 1200 w. 40c. Describes a joint used in the Lanchester motor car, consisting of a fluted shaft on which suitably slotted parts (worm gears, change gears, etc.) may be mounted.

Design and Construction of Automobile Crankshafts. P. M. Heldt. Automobile—Mar. 19, 08. 7 figs. 3500 w. 20c. Paper read before the Society of Automobile Engineers at Boston.

Epicyclic Gearing for Automobiles. T. A. Borthwick. Cass Mag—Apr., 08. 10 figs. 2600 w. 40c. An examination into the varieties of such mechanism as are employed in modern motor cars.

Gyrostatic Action—Its Effect on Steering. William W. Watson. Auto—Mar. 26, 08. 1200 w. 20c. Paper read before the Royal Automobile Club, London.

Motor-Car Design. F. W. Lanchester. Engg—Mar. 13, 08. 16 figs. 7000 w. Mar. 20. 13 figs. 6500 w. Each 40c. Paper read at the Incorporated Institution of Automobile Engineers Mar. 11. Considers a number of the problems peculiar to the design of automobiles, including worm-driving, screw propulsion and gyroscopic effects.

Multiple Unit Systems.

Multiple Unit Systems of Transportation. Joseph A. Anglada. Auto—Mar. 26, 08. 5 figs. 2300 w. 20c. Paper read before the Society of Automobile Engineers at Boston.

Racing Cars, Power and Speed of.

The Power and Speed of Racing Cars. Herbert L. Towle. Automobile—Apr. 9, 08. 2 figs. 3200 w. 20c. Gives a curve of tractive effort from which the performance and required gear ratio of any standard racing car may be obtained.

CIVIL ENGINEERING

BRIDGES.

Arches.

A Hinged Masonry Arch with Zinc Filled Joints. Cem—Mar., 08. 2 figs. 1000 w. 40c. Describes a French arch bridge of 82-ft. span, hinged at abutments and crown, the resistance of the joints being considerably increased by pouring zinc in them.

A Three-Hinge Reinforced-Concrete Skew Arch Bridge in Denver, Colo. Eng Rec—Mar. 21, 08. 6 figs. 4500 w. 20c. Describes numerous features of design and the methods employed in construction.

Blackwell's Island Bridge.

The Channel Spans of the Blackwell's Island Bridge. Eng Rec—Apr. 11, 08. 11 figs. 3800 w. 20c.

Cairo, Egypt.

New Road Bridges Over the Nile at Cairo. Engr (Lond)—Mar. 13, 08. 3 figs. 1400 w. Mar. 20. 8 figs. 1500 w. Each 40c.

Columbia River, Ore.

The Bridging of the Columbia and Willamette Rivers between Vancouver, Wash., and Portland, Ore. Ralph Modjeski. Ry Age—Mar. 20, '08. 12 figs. 2000 w. 20c.

Lincoln Once Reported to a Man's Creditors

that he had a table and two chairs valued at $3.75, a wife and baby worth at least $50,000 and there was a rat hole in one corner of his office that would bear looking into.

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Construction Methods in U. S.

Bridge Construction in the United States. F. Dircksen. Z V D I—Feb. 28, 08. 1 fig. 12,000 w. Mar. 7, 15 figs. 8000 w. Mar. 21, 42 figs. 7000 w. Mar. 28, 55 figs. 6000 w. Apr. 4, 24 figs. 5000 w. Each 60c.

Erection.

Cantilever Bridge Erection on the Guatemala Northern Railway. Eng Rec—Apr. 4, 08. 3 figs. 1400 w. 40c.

Erecting the Springfield Bridge on Semi-Suspended Falsework. Eng Rec—Apr. 4, 08. 2 figs. 1700 w. 40c. Gives details of bridge No. 111 of the Boston & Albany R. R. crossing the Connecticut River between Springfield and West Springfield, Mass., with seven 176-ft. spans.

Notes on the Erection of Bridges.—IX. Ry Engr—March., 08. 6 figs. 3400 w. 40c.

Floors.

Tests of Reinforced-Concrete Floor Plates for Bridges. Cem—Mar., 08. 4 figs. 1500 w. 40c.

Waterproofing Ballasted Bridge Floors at Schenectady, N. Y. Eng Rec—Mar. 28, 08. 7 figs. 3600 w. 20c.

Latticing.

The Latticing Requirements of Built-up Steel Columns. F. von Emperger. Beton u Eisen. Feb. 19, 08. 1 fig. 2500 w. Mar. 12, 4 figs. 1800 w. Each $1.

Long-Span Trusses.

Modern Simple Bridge Trusses of Long Span. C. R. Young. Can Engr—Apr. 3, 08. 5 figs. 2400 w. 20c.

Manhattan Bridge.

Methods and Plant Used in Placing Concrete and Masonry for Brooklyn Anchorage for Manhattan Bridge. Gustave Kaufman. Engg Contr—Mar. 18, 08. 3 figs. 3200 w. 20c. Abstract of a paper read before the Brooklyn Engineers' Club, May 10, 06.

The Erection of the Manhattan Bridge. Eng Rec—Apr. 4, 08. 7 figs. 2600 w. 40c. Describes work on the Manhattan Bridge across the East River between the Brooklyn Bridge and the Williamsburg Bridge, New York City.

Piers, Renewal of.

Renewing Illinois River Bridge Piers, Toledo, Peoria & Western R. R. Ry Age—Mar. 20, 08. 3 figs. 1300 w. 20c.

Quebec Bridge.

Appendix 12, Report of Quebec Bridge Commission. Eng Rec—Apr. 11, 08. 6 figs. 6800 w., 20c.

Appendix 13, Report of Quebec Bridge Commission. Eng Rec—Apr. 11, 08. 3 figs. 2000 w. 20c. An examination of the various full-size column tests that have been made in America accompanied by diagrams showing the results of these tests.

Appendix 14, Report of Quebec Bridge Commission. Eng Rec—Apr. 11, 08. 1 fig. 1200 w. 20c.

A Summary of Tests of Large Columns: Appendix 13 to the Quebec Bridge Commission's Report. Eng News—Apr. 9, 08. 3 figs. 2000 w. 20c. A study of all large-size column tests that have ever been made, which is summarized in three diagrams.

Report of the Royal Commission on the Cause of the Collapse of the Quebec Bridge. Eng Rec—Mar. 14, 08. 60,000 w. 20c.

The Quebec Bridge Disaster. Carl Jensen. Engg—Apr. 3, 08. 2500 w. 40c. A criticism of some of the best-known formulas for proportioning the latticing of struts, with suggestions for their improvement.

Railway Bridge Superstructures.

Iron and Steel Structures—Report of the Committee on Impact Tests. F. E. Turneaure, C. H. Cartlidge, C. L. Crandall. Ry Age—Mar. 20, 08. 2400 w. 20c. Abstract of a report presented at the ninth annual meeting of the American Railway Engineering and Maintenance of Way Association, Chicago, Mar. 17, 18 and 19, 08.

Short Railway Girder Bridges of Rolled Steel Shapes Embedded in Concrete. Herr Chaussette. Zent d Bau—Mar. 28, 08. 5 figs. 2000 w. 40c. Describes a construction used in Germany because of its cheapness, adaptability, etc.

Strengthening a Double-Line Railway Bridge. Engr (Lond)—Mar. 20, 08. 5 figs. 2200 w. 40c. Describes a method of strengthening a girder bridge, which consists of erecting a new girder between the two outside ones and slinging the cross girders from it, which is extremely simple, and not only strengthens the cross girders, but also relieves the main girders of a certain portion of their load.

The Replacement of the Old Steel Superstructure of the Railway Bridge over the Elbe, at Magdeburg, Germany. W. Dietz. Z V D I—Mar. 14, 08. 27 figs. 4500 w. 60c. Describes the new structure and the methods of removing the old spans and placing the new ones.

Standards for Austrian Steel Railway Bridge Superstructures. R. Jaussner. Zeit Oest Ing u Arch—Feb. 28, 08. 16 figs. 1800 w. 80c. Gives revised tables and data for dealing with the increased loadings now used.

Reinforced-Concrete Bridges.

A New Ferro-Concrete Bridge. Engr (Lond)—Apr. 3, 08. 15 figs. 2400 w. 40c. Describes construction of an English highway bridge embodying a number of features of novel and distinctive character.

A Peculiar Concrete and Steel Bridge in France. Eng News—Mar. 26, 08. 5 figs. 1200 w. 20c. Describes a railway bridge across the Guindy, on the line between Treguier and Perros, on the northeastern coast of France, which is notable not only

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A New Transporter Bridge at Warrington. Engr (Lond)—Mar. 27, 08. 7 figs. 3800 w. Apr. 3, 8 figs. 2400 w. Each 40c. Describes a bridge over the Mersey, near Liverpool, consisting of a single pair of main suspension cables, uncradled, with straight inclined back stays, and vertical hangers from the cables for the platform; the runway being stiffened by a pair of open-type through girders without hinges at mid-span.

Vibration of Structures, Time of.

The Time of Vibration of Loaded Structures. W. M. Wallace. Engg—Mar. 13, 08. 2 figs. 700 w. 40c. Describes a method of calculation thought to be original, and giving results within 1% of practical tests.

Washington, D. C.

The Connecticut Avenue Bridge at Washington, D. C. Eng News—Mar. 26, 08. 2 figs. 1100 w. 20c.

EARTHWORK, ROCK EXCAVATION, ETC.

Grubbing.

Methods of Grubbing Stumps and Trees. Engg-Contr—Mar. 25, 08. 6 figs. 2200 w. 20c.

Methods of Grubbing Stumps and Trees with Machines. Engg-Contr—Apr. 8, 08. 4 figs. 1300 w. 20c.

A Continuous Unloader. Lewis A. McArthur. Cal Jl Tech—Feb., 08. 1 fig. 1600 w. 20c. Describes a platform built of heavy 30-ft. timbers radiating from the base of a large mast, the outside ends of the timbers being supported by iron rods from the top of the mast. On this platform is built a circular track from which the cars are dumped. Used on heavy fills on the W. P. Ry. in California.

ENGINEERING CONSTRUCTION.

Bins.

Storage Bins for a German Plaster Works. K. von Terzaghi. Beton u Eisen—Feb. 19, 08. 5 figs. 2500 w. $1. Gives details and calculations used in the design.

Buildings.

A Concrete Manufacturing Building. Cem Age—Mar., 08. 13 figs. 1500 w. 20c. Describes the reinforced-concrete factory of the Wolf Manufacturing Co., at Philadelphia—a substantial structure which exemplifies the utility of concrete.

A Reinforced-Concrete Oil Tank Building: Design, Construction and Cost. Charles F. Leonard. Am Gas Lt Jl—Apr. 6, 08. 2 figs. 2400 w. 20c. Paper read at the Thirty-Eighth Annual Meeting, New England Association of Gas Engineers.

A Ten-Story Building in Forty-Seven Working Days. Eng Rec—Apr. 4, 08. 2 figs. 1800 w. 40c. Describes methods used in rapid construction work on a New York concrete factory building.

Erecting Columns in Occupied Offices. Eng Rec—Apr. 4, 08. 1000 w. 40c. Describes the methods used in the old part of the Singer Building, New York City.

Hippodrome Building at Cleveland, Ohio. James A. Joyce. Eng News—Apr. 9, 08. 7 figs. 2000 w. 20c.

Modern High Buildings. E. W. Hagerty. Can Engr—Apr. 3, 08. 1 fig. 3500 w. 20c.

Reinforced-Concrete Power Station. Cal Jl Tech—Mar.-Apr., 08. 2 figs. 2600 w. 20c. Describes the construction of the Georgetown power plant of the Seattle Electric Co., a reinforced-concrete unit building, which is to be duplicated as growth demands.

The Construction of the City Investing Building, New York. Eng Rec—Apr. 4, 08. 4 figs. 5100 w. 40c.

The Construction of the Hudson Companies' Buildings, New York. Eng Rec—Apr. 4, 08. 4 figs. 2600 w. 40c.

The Engineering Features of the New Cleveland Hippodrome. Ir Tr Rev—Apr. 9, 08. 10 figs. 2900 w. 20c. Describes the steel construction and methods used on the foundations.

The Erection of the Metropolitan Life Building Tower, New York. Eng Rec—Apr. 4, 08. 3 figs. 3200 w. 40c.

The Fire at the Dayton Motor Car Works. J. B. Gilbert. Eng Rec—Mar. 28, 08. 6 figs. 1600 w. 20c. Furnishes a very interesting demonstration of the efficiency of reinforced concrete as a fireproof building material.

The Phelan Building, San Francisco. Eng Rec—Mar. 28, 08. 8 figs. 2700 w. 20c. Describes the 11-story steel office building in which special provisions are made for resisting earthquake shocks.

The San Francisco Earthquake of April 18, 06. Joseph H. Harper. Jl Asso Engg Soc—Feb., 08. 7000 w. 50c. Paper read before the Montana Society of Engineers at Bozeman, Mont., Jan. 11, 08.

Caisson, Righting of an Overturned.

The Construction of the Base of Baltimore Light, in Chesapeake Bay. H. Prime Kieffer. Eng Rec—Mar. 14, 08. 7 figs. 5100 w. 20c. Describes methods used in righting a large pneumatic caisson which had been overturned in a storm.

Chimneys.

Reinforced-Concrete Chimneys. Sanford E. Thompson. Cem Age—Mar., 08. 5 figs. 1600 w. 20c.

The Design of Ferro-Concrete Chimneys. C. Percy Taylor. Engg—Mar. 13, 08. 7 figs. 4400 w. 40c. Gives formulas resulting from an analysis of the stresses and applies them to the checking of the dimensions of chimneys which recently failed.

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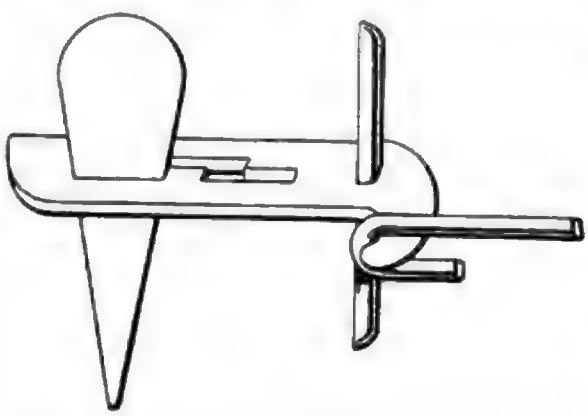

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The Removal of a Tall Steel and Brick Smoke Stack. Eng Rec—Mar. 14, 08. 1 fig. 900 w. 20c. Describes the removal at the Lorain plant of the National Tube Works, of a brick-lined steel smoke stack 225 ft. high and 11 ft. in diameter.

Concrete Poles.

The Design of Hollow Reinforced-Concrete Poles. F. Schuele. Beton u Eisen—Mar. 12, 08. 5 figs. 2500 w. $1. Gives method of calculation, illustrative examples and data on recent tests.

Cofferdam.

Method of Building a Small Cofferdam. W. H. Boughton. Engg-Contr—Apr. 8, 08. 1100 w. 20c. Abstracted from a paper read before the Ohio Engineering Society.

Dams.

A Combination Dam and Bridge. Eng News—Apr. 9, 08. 2 figs. 500 w. 20c. Describes a dam consisting of a reinforced-concrete deck-slab, in the shape of the ordinary gravity dam sections, supported at intervals by interior reinforced-concrete buttresses. The bridge is formed by continuing these interior supporting buttresses up through the deck-slab and carrying, upon their top, stringers bearing the railway.

A Concrete and Earth Diversion Dam in California. Eng Rec—Mar. 14, 08. 2 figs. 5400 w. 20c. Describes the John Days diversion dam on the Eel River, Mendocino County, Cal., a concrete and earth structure having a total length of 630 ft. on top.

A Large Irrigation and Power Project in Southern California. Eng Rec—Apr. 4, 08. 5 figs. 3500 w. 40c. Describes dam and reservoir and methods of construction used in a project in the San Bernardino Mountains.

Construction of the Main Dam of the Croton Falls Reservoir. Eng Rec—Mar. 28, 08. 5 figs. 4700 w. 20c.

Derrick.

A 40-Ton Wooden Guyed Derrick. Eng Rec—Apr. 4, 08. 1 fig. 1100 w. 40c. Describes a guyed derrick with a 75-ft. mast and a 66-ft. boom recently designed and constructed for the erection of the 6,000 tons of structural steel in the Singer Building, New York.

Domes and Vaults.

The Design of Domes, Vaults and Conical Coverings. Edward Godfrey. Conc Engg—Mar., 08. 3 figs. 3900 w. 20c.

Foundations and Piling.

Concrete Pile Foundations. M. Deutsch. Ind Mag—Mar., 08. 2000 w. 20c.

Foundation Construction of the New State Capitol of South Dakota. Samuel H. Lea. Eng Rec—Apr. 4, 08. 2 figs. 1800 w. 40c.

Foundations, With Special Reference to Modern Methods and Plant. Percival M. Fraser. Contr Jl—Apr. 1, 08. 10,000 w. 40c. Paper read at the Institute of Sanitary Engineers.

Foundations. A. B. Clark. Proc Engrs Club—Jan., 08. 4 figs. 3700 w. 80c. Paper read Dec. 7, 07, before the Engineers' Club of Philadelphia. Describes some of the less-known phases of development on Manhattan Island in the last fifteen years.

Loading Test of a Compressol Foundation Pile. F. von Emperger. Beton u Eisen—Feb. 19, 08. 8 figs. 5000 w. $1.

Repairing Foundations with Grout and by Divers. Eng Rec—Apr. 4, 08. 2800 w. 40c.

Special Foundations for a New Edison Sub-Station. (New York City.) Eng Rec—Apr. 4, 08. 1 fig. 1100 w. 40c. Describes methods used in soft, wet ground.

The Development of Building Foundations. Frank W. Skinner. Eng Rec—Apr. 4, 08. 16 figs. 1200 w. 40c. Discusses methods used in building foundations of high buildings in the congested districts of New York, Chicago, and other large cities.

The Strauss System of Concrete Piling. Beton u. Eisen—Mar. 12, 08. 7 figs. 800 w. $1. Describes a Russian system in which a hole is driven by means of a well drill and in which the concrete is deposited and then compacted by a pile driver.

Gasholder, Concrete.

The Construction and Costs of a Concrete Gasholder Tank. E. Frith. Am Gas Lt Jl—Mar. 23, 08. 4 figs. 2400 w. 20c. Paper read before the Manchester District Institution of Gas Engineers.

Pipe Trestle.

A Reinforced-Concrete Sewer Pipe Trestle. Eng Rec—Mar. 14, 08. 1 fig. 1700 w. 20c. Describes a construction recently built in Los Angeles, Cal., to carry an intercepting sewer across the Los Angeles River.

Reinforced-Concrete Construction.

Architectural Expression in a New Material. Arch Rec—Apr., 08. 9 figs. 6500 w. 40c. Discusses the practical and esthetic problems of design in reinforced concrete.

Calculations for Reinforced-Concrete Construction. R. Wuczkowski. Beton u. Eisen—Feb. 19, 08. 4 figs. 1200 w. $1. Gives a simple formula for use on rectangular and T-section beams.

Concrete Inspection. A. D. Williams, Jr. Conc Engg—Mar., 08. 2 figs. 4500 w. 20c. Discusses the duties of an inspector of concrete work and enumerates the points to which his attention should be directed in such work.

Cost of Reinforced-Concrete Work. Cem Era—Mar., 08. 2000 w. 20c. Discusses the tendency of contractors to estimate too low on concrete construction.

Cracks in Reinforced-Concrete Beams. F. von Emperger. Zent d Bau—Mar. 4, 08. 8 figs. 3000 w. 40c. Gives graphical discussion.

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Economical Arrangement of Mixing Plants. R. W. Maxton. Conc Engg—Mar., 08. 900 w. 20c.

Graphostatic Calculations for Reinforced-Concrete Construction. G. Ramisch. Beton u. Eisen—Feb. 19, 08. 4 figs. 1000 w. $1. Gives mathematical relations and graphical constructions derived therefrom.

Methods and Costs. W. H. Mason. Cem Age—Mar., 08. 4 figs. 3700 w. 20c.

New Researches on Reinforced Concrete. M. R. von Thullie. Beton u Eisen—Feb. 19, 08. 4 figs. 1200 w. $1. Discusses the effect of repeated loading of beams.

Notes on Reinforced Concrete (Con.). Prof. A. W. French. Jl Wor Poly Inst—Mar., 08. 5 figs. 3100 w. 40c. Gives straight-line and parabolic stress analysis of simple rectangular beams.

System in Estimating Reinforced-Concrete Building Construction. Robert E. Lamb. Conc Engg—Mar., 08. 800 w. 20c. Describes one system of making up a bid on reinforced buildings which will be simple, and, if fully worked out, will result in an estimate which is practically self-checking.

The Austrian Government Regulations for Concrete and Reinforced-Concrete Construction. Cem—Mar., 08. 1800 w. 40c. Gives the regulations in force for highway bridges.

The Development of a Practical Method of Reinforcing Concrete. H. F. Porter. Conc Engg—Mar., 08. 3 figs. 2800 w. 20c. An address delivered at Toronto University, Toronto, Canada.

The Edison Concrete House. E. S. Larned. Cem Age—Mar., 08. 2 figs. 4500 w. 20c. Gives conclusions of engineers concerning the practicability of the project, and states the purpose of the inventor.

The Practical Problems Involved. Percy H. Wilson. Cem Age—Mar., 08. 1800 w. 20c. Discusses the constructional questions involved in the Edison concrete house.

The Unit vs. the Loose-Bar System of Reinforced-Concrete Construction. Emile G. Perrot. Eng News—Mar. 26, 08. 1800 w. 20c. Paper read before the National Association of Cement Users, Fourth Annual Meeting, Buffalo, N. Y., Jan. 24, 08.

The Use of Reinforced Concrete in Engineering and Architectural Construction in America. Ernest R. Matthews. Surveyor—Mar. 27, 08. 9 figs. 6000 w. 40c. From a paper read lately before the Royal Society of Arts.

Reservoirs.

Reservoir Construction in Rochester, N. Y. Mun Engr—Apr., 08. 4 figs. 800 w. 40c. Gives information concerning the construction of Cobb's Hill reservoir, which is a distributing reservoir for the water works of Rochester, N. Y.

Some Construction Methods at the Croton Falls Reservoir. Eng Rec—Apr. 11, 08. 5 figs. 4000 w. 20c.

The Reinforced-Concrete Reservoirs and Aqueduct of Mexico City. James D. Schuyler. Eng Rec—Mar. 28, 08. 9 figs. 3900 w. 20c. Describes the building of four large circular reservoirs, lined and roofed with armored concrete, for the distribution system of the new waterworks of Mexico City.

Retaining Walls.

Comparative Costs of Gravity and Reinforced-Concrete Retaining Walls. Frank A. Bone. Eng News—Mar. 26, 08. 4 figs. 800 w. 20c.

Ropeway.

Wire Ropeway in the North Argentine Cordilleras. Engg—Mar. 20, 08. 20 figs. 3200 w. Apr. 3, 10 figs. 5000 w. Each 40c. Describes a 21-mile ropeway connecting the Famatine mines and the railway Chilecito, having a capacity of 4 tons per hour on the up journey (11,500-ft. rise) and 40 tons on the down journey, at about 5.5 miles per hour.

Sewers.

A Large Double-Barrel Sewer Built Across a Salt Marsh, Borough of the Bronx, New York City. Eng Rec—Apr. 4, 08. 4 figs. 2100 w. 40c.

A Private Sewer Tunnel in Rock Excavation. Eng Rec—Apr. 11, 08. 7 figs. 3200 w. 20c. Describes construction of storm-water sewer for draining the depressed yard for suburban train service at the N. Y. C. & H. R. R. terminal, New York City.

Reinforced-Concrete Intercepting and Outfall Sewer, Waterbury, Conn. Wm. Gavin Taylor. Eng News—Mar. 26, 08. 15 figs. 4100 w. 20c.

The New Main Intercepting Sewer at Waterbury, Conn. Wm. Gavin Taylor. Eng Rec—Apr. 4, 08. 7 figs. 1400 w. 40c.

Steel Construction.

Erecting an Open Hearth Furnace Building. Eng Rec—Apr. 4, 08. 3 figs. 900 w. 40c. Describes work on a 172½x448-ft. steel building for the Pennsylvania Steel Co., at Steelton, Pa., about 117 ft. in extreme height and containing 5,610,000 lbs. of structural steel.

Steel Construction for Long-Span Floors in the Chicago Athletic Association Building. Eng News—Mar. 19, 08. 5 figs. 800 w. 20c.

Structural Design.

Notes on Structural Designing. E. A. Stone. Can Engr—Apr. 3, 08. 2400 w. 20c.

Similar Structures with Corresponding Loads. Prof. A. Inokuty. Pract Engr (Lond)—Apr. 3, 08. 1 fig. 3500 w. 40c. Discusses the limitation of size due to the fact that weight increases as the cube of dimensions, while power to sustain loads increases only as the square.

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Lowering the Traction Tunnels Under the Chicago River. L. F. Wilson. Sc Am—Apr. 4, 08. 3 figs. 900 w. 20c.

Progress on the Bridge Loop Subway, New York City. Eng Rec—Apr. 4, 08. 4 figs. 2300 w. 40c.

The Effect of Tunneling Operations on St. Paul's Cathedral, London. Eng Rec—Mar. 28, 08. 2600 w. 20c.

The Second Raton Hill Tunnel, New Mex., of the Atchison, Topeka & Santa Fe Railway. Eng Rec—Apr. 4, 08. 8 figs. 2300 w. 40c.

The Strand to Embankment Subway. Engr (Lond)—Mar. 13, 08. 10 figs. 3500 w. 40c. Describes the engineering features of the construction of the tunnels.

The United States Capitol Subways. W. J. Knight. Eng Rec—Mar. 21, 08. 9 figs. 2400 w. 20c. Describes the two recently completed reinforced-concrete subways connecting the United States Capitol with the Senate and House office buildings.

Waterproofing.

Some Notes on Waterproofing. E. P. Goodrich. Wtrpfg & Firepfg—Feb.-Mar., 08. 600 w. 20c.

Waterproof Cement and the Waterproofing of Concrete. Brit Clay Wkr—Mar., 08. 1400 w. 40c.

Waterproofing Concrete Structures. James L. Davis. Cem—Mar., 08. 7500 w. 40c. Describes the laboratory of the Board of Water Supply of the City of New York.

What Waterproofing May do for the Cement Industry. A. C. Horn. Waterproofing & Fireproofing—Feb.-Mar., 08. 2800 w. 20c. Paper read before the Vulcan Assembly of Philadelphia, Feb. 22, 08.

MATERIALS.

Cement and Concrete.

Cement Stucco in Argentine. Cem Age—Mar., 08. 11 figs. 900 w. 20c. Shows how a plastic material has been used by the architects of Buenos Ayres, and gives examples of modern structures in this South American city.

Portland Cement: Its Uses, Improved Manufacture, and Methods of Testing It. G. M. R. Layton. Brit Clay Wkr—Mar., 08. 4000 w. 40c. A recent lecture to the students of the Northern Polytechnic Institute, London.

The Dangers of Cement Analysis. Brit Clay Wkr—Mar., 08. 700 w. 40c. Discusses necessity for a standard method and gives table of widely-different results obtained by analysis of same sample in six laboratories.

The Modulus of Shearing of Concrete. Herr Heintel. Beton u. Eisen—Mar. 12, 08. 7 figs. 1500 w. $1. Gives values deduced from Bach's beam tests.

Cement Works.

An English Electrically-Driven Cement Works. Eng Rec—Apr. 11, 08. 6 figs. 2100 w. 20c.

Inland Portland Cement Works. Engr (Lond)—Mar. 20, 08. 12 figs. 3500 w. 40c. Describes a modern British cement works at Cambridge.

Hollow Brick and Tile.

Fireproof Construction. M. M. Sloan. Arch & Bld Mag—Apr., 08. 6 figs. 2100 w. 40c. V.—Hollow brick and tile.

Iron, Rusting of.

The Rusting of Iron. Engg—Mar. 13, 08. 3500 w. 40c. A résumé of recent researches into the theory of rusting.

Sand.

The Value of Sand in Concrete Construction. Cem Age—Mar., 08. 3200 w. 20c. Report of the Section on Testing Cement and Cement Products, presented at the National Association of Cement Users at Buffalo, Jan. 20-25, 08.

Slag Brick.

The Manufacture of Concrete Brick from Blast Furnace and Other Slag. Josiah Butler. Ir Tr Rev—Mar. 19, 08. 4800 w. 20c. Abstract of a paper presented before the Staffordshire Iron & Steel Institute, Dudley, England, Jan. 18, 08.

Stone-Crushing Plant.

A Commercial Stone-Crushing Plant at North Le Roy, N. Y. John Rice. Eng Rec—Apr. 4, 08. 1 fig. 1800 w. 40c. Describes a plant the average production of which is about 50,000 tons monthly of 2½-in. stone, including the smaller sizes.

Timber.

A Graphical Comparison of Various Log Rules. Arthur H. Morse. Eng News—Apr. 9, 08. 2 figs. 1700 w. 20c.

Kansas City Plant of the American Creosoting Co. Ry Age—Apr. 3, 08. 11 figs. 3400 w. 20c. Describes a recently completed plant which will supply under contract about 750,000 treated ties annually for a term of 20 years to the C. R. I. & P. Ry.

The Shrinkage of White Oak. Walker L. Wellford. Wood Craft—Apr., 08. 900 w. 20c. Read at the St. Louis Convention of the National Coopers' Association.

RIVERS, CANALS, HARBORS.

Breakwater.

A Novel Breakwater for Algoma Harbor, Wis. Eng Rec—Mar. 21, 08. 3 figs. 1000 w. 20c. Describes a breakwater consisting of about 928 lin. ft. of pile or plank crib pier and about 500 lin. ft. of breakwater made of reinforced-concrete caissons.

Canal-Boat Haulage.

Notes on Electric Haulage of Canal Boats. Lewis B. Stillwell and H. St. Clair Putnam. Proc Am Inst Elec Eng—Apr., 08. 4 figs. 1000 w. 80c. An appendix in which re-

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sults given in the paper are compared with those obtained in the very complete tests made by Sympher Thiele, and Block on the Rhine-Weser Canal in 1906.

Coast Protection.

Foreshore Protection of the West German Coast of the Baltic Sea. Zent d Bau—Apr. 1, 08. 36 figs. 4000 w. 40c.

The Principles and Practice of Coast Protection. Frank J. Gray. Contr Jl—Mar 18, 08. 12 figs. 4500 w. 40c. Takes up the planning and construction of groynes for arresting the traveling shingle and retarding the alongshore currents so that they will deposit their suspended material and then build up and maintain the slope of the foreshore.

The Royal Commission on Coast Erosion.—III. Engr (Lond)—Mar. 13, 08. 2500 w. 40c. A continuance of a review of the statements of the engineering experts, and dealing with the evidence of surveyors, etc.

Dredging.

Clay-Cutting Suction-Dredger. Engg—Apr. 3, 08. 12 figs. 1700 w. 40c. Describes a dredge constructed for filling in the new extension to the north of Lincoln Park, Chicago.

Dredging Equipment of the Panama Canal. F. B. Maltby. Proc Engr Club, Phila.—Jan., 08. 4000 w. 80c. Paper read Jan. 4, 08, before the Engineers' Club of Philadelphia.

The Cost of Hydraulic Dredging on the Mississippi River. Eng Rec—Mar. 21, 08. 1800 w. 20c. A memorandum by Lieut.-Col. Clinton B. Sears for the Board of Engineers on the Improvement of the Ohio River. Gives data relating to the six best dredges in use by the Mississippi River Commission as to first cost, repairs and betterments, operating expenses, deterioration, and results obtained.

Docks.

Electric Power in Docks. C. E. Taylor. El Engr—Mar. 13, 08. 7 figs. 4000 w. 40c. Paper read before the Institution of Electrical Engineers.

Terminal Improvements at Ashtabula Harbor for the Pennsylvania Lines. Ry & Eng Rev—Mar. 14, 08. 13 figs. 700 w. 20c. Describes the increased facilities for handling coal and ore at this Erie port.

The Contractor's Plant and Methods on Mare Island Dry Dock No. 2. Eng Rec—Apr. 4, 08. 9 figs. 9200 w. 40c.

Erie Barge Canal.

Construction Work on the Erie Barge Canal. James C. Mills. Cass Mag—Apr., 08. 14 figs. 3200 w. 40c.

Progress on Section 11, New York State Barge Canal. Eng Rec—Apr. 4, 08. 5 figs. 1400 w. 40c.

Great Lakes-Gulf Waterway.

Some of the Engineering Problems Involved in the Construction of a Deep Waterway from the Great Lakes to the Gulf of Mexico. J. A. Ockerson. Jl Assoc Engg Socs—Feb., 08. 18 figs. 8200 w. 50c. Paper read before the Engineers' Club of St. Louis, Feb. 5, 08.

Irrigation Work.

Lining of Ditches and Reservoirs to Prevent Seepage Losses (Cont.). Prof. B. A. Etcheverry. Irrig Age—Apr., 08. 7 figs. 2000 w. 20c. Discusses cement mortar linings.

Reclamation Projects in Montana. H. N. Savage. Jl Assoc Engg Socs—Feb., 08. 2400 w. 50c. Paper read before the Montana Society of Engineers, Bozeman, Mont., Jan. 11, 08.

SURVEYING, MEASUREMENTS.

Curves, Formulas for.

General Formulas for Simple Curves. J. C. Locke. Eng News—Mar. 26, 08. 20c.

Surveyor's Tools.

Some Useful Tools for Surveyors Working Alone. Thaleon Blake. Eng News—Mar. 19, 08. 7 figs. 800 w. 20c. Describes a substantial marking pin and several devices for holding a surveyor's rod.

ECONOMICS

Commercial Research.

Commercial Research. C. E. Skinner. Elec Jl—Apr., 08. 9000 w. 20c. Address delivered before the Engineering Assembly of Purdue University, Jan. 20, 08. Discusses investigations undertaken for the purpose of adding to human knowledge with the direct view of securing commercial returns in a reasonable time.

Conservation of Natural Resources.

Conservation of the Natural Resources of the United States: The Work of the U. S. Geological Survey. Herbert M. Wilson. Eng News—Apr. 9, 08. 9500 w. 20c. Published by permission of the Director of the United States Geological Survey. Discusses the various investigations carried out by this government bureau.

Cost Accounting.

A Complete System for the Purchasing Department. J. Cecil Nuckols. Eng Mag—Apr., 08. 6 figs. 1700 w. 40c.

Additional Methods of Tracing the Progress of the Work. Oscar E. Perrigo. Ir Tr Rev—Apr. 2, 08. 3 figs. 3700 w. 20c. Seventh of a series of articles on cost-keeping and shop management.

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Time Keeping and Distribution of Cost Systems. J. H. K. Shannahan, Jr., and E. G. Reist. Business Man's Mag—Apr., 08. 1 fig. 1400 w. 20c. Describes the unique systems now in use by the Maryland Steel Co. of Sparrows' Point, Md.

Employers' Liability, Law of.

The Law of Electric Light Companies. J. E. Brady. Elec Wld—Apr. 4, 08. 2100 w. 20c. Discusses liability of electric companies to their employees.

Engineers and Public Affairs.

The Engineer's Activity in Public Affairs—Public Utility Commission's and Franchise Valuations. Henry Floy. Proc A I E E—Apr., 08. 8000 w. 80c. Paper presented before the American Institute of Electrical Engineers, New York, Apr. 10, 08.

Factory Management.

An Analysis of Machine-shop Methods. Holden A. Evans. Am Mach—Apr. 11, 08. 5 figs. 5800 w. 20c. Discusses the inefficiency in Government shops which is often due to day-work, lack of system in tools, material and organization.

Effective Machine-shop Organization. Alexander Taylor. Am Mach—Mar. 19, 08. 1600 w. 20c. States methods used by the Westinghouse Elec. & Mfg. Co. for fixing responsibility, increasing productive periods and floor space and decreasing clerical labor.

Increasing the Efficiency of Machines. Oscar E. Perrigo. Southern Machy—Apr., 08. 4 figs. 2800 w. 20c.

Making the Most of Floor Space. O. W. Mueller. Factory—Mar., 08. 5 figs. 1200 w. 40c. Shows how a machine shop can be laid out to secure economy in production.

Maximum Production Through Organization and Supervision. C. E. Knoeppel. Eng Mag—Apr., 08. 4000 w. 40c. Deals chiefly with the adjustment of the internal organization to the utmost working efficiency.

Producing Power at Lowest Cost. O. M. Becker and W. J. Lees. Factory—Mar., 08. 4 figs. 2300 w. 40c. V.—Organization of the Operatinf Force. Shows how responsibilities in the plant can be fixed, what men should be chosen for definite positions and how the operating force should be handled.

Running a Factory by Schedule. Robert Daily. Factory—Mar., 08. 4 figs. 1400 w. 40c. V.—Shows in detail how daily reports of one of the originating departments—the foundry—are summarized for the quick inspection of the work's manager.

The Fundamental Principles of Work Organization and Management. P. J. Darlington. Eng Mag—Apr., 08. 5200 w. 40c.

Hygienics of Illumination.

Hygienics of Gas and Electricity. Samuel Rideal. Prog Age—Mar. 27, 08. 3500 w. 20c. Paper recently presented to the Royal Sanitary Institute of London. Gives data upon which it is argued that the choice between the two system does not depend on hygienic considerations.

Industrial Conditions, Workman's View of.

American Industrial Conditions from a Workman's Viewpoint. Eng Mag—Apr., 08. 1500 w. 40c.

Industries, Classification of.

The Classification of Industrial Enterprises. William D. Ennis. Stev Inst Ind—Jan., 08. 6500 w. 60c. Study of the conditions which may serve to classify industries so as to determine the justness of their standards of process, organization and equipment.

Shop Education.

Progressive Shop Education—A Suggestion. Frederick A. Waldron. Am Mach—Apr. 2. 08. 4100 w. 20c. Outlines a continuous and systematic course to train shopmen for responsibilities of effective foremen, superintendents or managers.

Wage Systems.

The Payment of Wages. Forrest E. Cardullo. Ir Tr Rev—Mar. 19, 08. 4700 w. 20c. Discusses three systems in general use and sets forth the advantage of an ideal system in which results rather than time spent are the basis of payment.

ELECTRICAL ENGINEERING

ELECTROCHEMISTRY.

Storage Batteries.

The Care of Storage-Battery Cells. William Kavanagh. Power—Mar. 17, 08. 2 figs. 1000 w. 20c.

ELECTROPHYSICS.

Alternate-Current Analysis.

Vector Algebra for Alternate-Current Problems. William Cramp and C. F. Smith. El Engr—Mar. 20, 08. 3 figs. 2600 w. 40c. Suggests an improvement in the notation for dealing with alternate-current problems.

Electric Discharges Through Gases. Engg—Mar. 13, 08. 1 fig. 3200 w. Mar. 20, 2100 w. Mar 27. 4 figs. 1900 w. Apr. 3. 2400 w. Each 40c. Résumés of a series of four lectures at the Royal Institute by Prof. J. J. Thomson.

GENERATORS, MOTORS, TRANSFORMERS.

Alternators in Parallel.

Alternators in Parallel. Morgan Brooks. West Elecn—Mar. 21, 08. 12 figs. 1300 w. 20c. Paper presented before the Electrical Section of the Western Society of Engineers, Chicago, Mar. 11, 08. Gives a diagram showing what change as to power in-

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Commutators, Truing of.

Truing Up Rotary Commutators. C. L. Greer. St Ry Jl—Apr. 4, 08. 2 figs. 600 w. 20c.

Direct-Current Motors.

Direct-Current Motors, Their Action and Control.—VI. F. B. Crocker and M. Arendt. Elec Wld—Apr. 4, 08. 14 figs. 1200 w. 20c. Describes speed control in motors with unsaturated magnetic circuits, in motors with high flux density of the pole tips and in interpole motors.

Heating of Armature Cores.

The Heating of Dynamo Armature Cores. G. Schmaltz. Elek Zeit—Feb. 27, 08. 5 figs. 1000 w. 40c.

Single-Phase Motors.

The Classification of Single-phase Motors. J. Jonas. Elek Zeit—Feb. 27, 08. 2000 w. 40c.

Transformer Design.

Transformer Design. E. Alm. Elek Zeit—Mar. 5, 08. 5 figs. 4500 w. 40c. Gives method of calculating dimensions of a transformer whose cost is a minimum under the given conditions of efficiency and heating.

LIGHTING.

Illuminating Engineering and Architects.

The Relation of Illuminating Engineering to Architects from the Engineer's Standpoint. E. L. Elliott. Am Gas Lt Jl—Mar. 23, 08. 4600 w. 20c. Paper read before the New York Section of the Illuminating Engineering Society.

Illumination.

Economical and Efficient Plans for Lighting Small Houses. J. R. Cravath and V. R. Lansingh. Elec Wld—Apr. 4, 08. 8 figs. 3200 w. 20c.

Influence of the Height of Suspension Upon Uniform Illumination. Alfred A. Wohlauer. Elec Wld—Mar. 21, 08. 5 figs. 2200 w. 20c.

On the Comparison of Public Street Lighting Effects. W. H. Y. Webber. Am Gas Lt Jl—Apr. 6, 08. 4 figs. 3600 w. 20c. From the "Gas World."

Problems in Illumination Made Easy. W. R. Bonham. West Elecn—Apr. 11, 08. 450 0w. 20c.

Mercury-Vapor Lamp.

A New Form of Cooper-Hewitt Mercury-vapor Lamp. F. H. Von Keller. West Elecn—Apr. 11, 08. 3 figs. 1600 w. 20c. Describes a form of lamp in which tilting is not necessary to effect starting.

Photometry.

A Calculator for the Use of Illuminating Engineers. Norman Macbeth. Ill Engr—Mar., 08. 3 figs. 1800 w. 40c.

A Convenient Method of Drawing the Rousseau Diagram. W. S. Kilmer. Ill Engr—Mar., 08. 1 fig. 800 w. 40c.

A Method of Determining Mean Spherical Candle-Power Without the Use of the Rousseau Diagram. Norman Macbeth. Ill Engr—Mar., 08. 1 fig. 300 w. 40c.

A New Graphic Method for Determining the Mean Spherical Intensity of a Lamp by the Length of a Straight Line When the Curve of Mean Meridianal Intensity is Given. A. E. Kennelly. Elec Wld—Mar. 28, 08. 9 figs. 400 w. 20c.

TELEGRAPHY AND TELEPHONY.

Automatic Telegraphy.

"Electro-Magnetic" Automatic Telegraphy. (The "Telepost.") Patrick B. Delany. Jl Fklin Inst—Mar., 08. 15 figs. 4500 w. 40c. Describes the inventor's system whereby 1000 words per minute can be transmitted over a wire.

Cables, Telephone and Telegraph.

Telephone and Telegraph Cables. F. Tremain. Elec Engg—Apr. 2, 08. 4500 w. 40c. A paper read at a meeting of the Newcastle Local Section of the Institution of Electrical Engineers, Mar. 23, 08.

Wireless Telegraphy.

A Directive System of Wireless Telegraphy. E. Bellini and A. Tosi. Elec Engg—Mar. 5, 08. 10 figs. 4000 w. 40c.

Wireless Telegraph Plant at the United States Naval Academy. Lieut.-Com. W. H. G. Bullard. Elec Wld—Mar. 21, 08. 4 figs. 2100 w. 20c.

TESTS AND MEASUREMENTS.

A. C. Measuring Instruments.

New Alternate-Current Instruments. W. E. Sumpner, D. S. C., and J. W. Record. Elec Engr—Mar. 27, 08. 13 figs. 4000 w. 40c. Paper read before the Institute of Electrical Engineers. Describes instruments which are the outcome of an investigation on the properties of iron-cored electromagnets for use in alternate-current instruments.

Central Station, Test of.

Test of a Medium Capacity Central Station. Howard S. Knowlton. Elec Wld—Apr. 4, 08. 4 figs. 3600 w. 20c.

Generators, Testing of.

Artificial Load for Testing Electrical Generators. R. K. Morcom and D. K. Morris. Elec Engr—Mar. 27, 08. 6 figs. 3300 w. Apr. 3. 8 figs. 2100 w. Each 40c. Paper read before the Institute of Electrical Engineers. Treats of the use of water resistances.

Tests of Electrical Machinery. Indus Elec—Feb. 25, 08. 5000 w. 40c. Gives a comparison of various methods.

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The Meter and Testing Department of the Hartford Electric Light Co. F. W. Prince. Elec Jl—Apr., 08. 3 figs. 3000 w. 20c.

Oscillograph.

The Oscillograph and Its Application. J. A. Johnson. Jl Wor Poly Inst—Mar., 08. 20 figs. 6500 w. 40c. Describes the instrument and the work it does, together with the uses it can be put to in connection with the work of a large power company.

TRANSMISSION, DISTRIBUTION, CONTROL.

Cables, Capacity of.

Capacity of Cables. F. J. O. Howe. Elecn—Mar. 20, 08. 3 figs. 3500 w. Mar. 27. 6 figs. 1800 w. Each 40c. Points out errors in measurements due to methods now used and gives results of an investigation which led to the design of a simply operated combined bridge for resistance, inductance and capacity measurements.

Choking Coils.

Choking Coils. Pract Engr (Lond)—Apr. 3, 08. 1 fig. 1800 w. 40c. Gives methods for calculating dimensions and windings of an apparatus to reduce alternating voltage.

Circuit Breakers.

Alliolith Circuit Breakers for High-Tension Systems. Indus Elec—Mar. 10, 08. 2 figs. 2400 w. 40c.

Circuit-Interrupting Devices. F. W. Harris. Elec Jl—Apr., 08. 7 figs. 1900 w. 20c. V.—Carbon-Break Circuit Breakers.

Fuses.

Fuse Phenomena. Prof. Alfred Schwartz and W. H. N. James. Elec Engg—Mar. 12, 08. 12 figs. 6000 w. 40c. Paper on the proposed standardization of fuses read before the Manchester Section of the Institute of Electrical Engineers, Mar. 31, 08.

Insulators for High-Voltage Lines.

High-Voltage Insulator Manufacture. Walter T. Goddard. Can Elec News—Apr., 08. 11 figs. 3200 w. 20c. (Conc.).

Porcelain Insulator for High-Voltage Lines. J. A. Sanford. Jl Wor Poly Inst—Mar., 08. 5000 w. 40c. Discusses requirements, manufacture, testing and current practice.

Poles, Concrete.

Concrete Poles. F. N. Rutherford. Can Engr. Apr. 3, 08. 1 fig. 1300 w. 20c.

Protective Devices.

Protective Device for High-Tension Transmission Circuits. J. S. Peck. Mech Engr—Mar. 20, 08. 8 figs. 300 w. Mar. 27. 12 figs. 2400 w. Each 40c. Abstract of paper read before the Institution of Electrical Engineers.

Protective Relays. M. C. Rypinski. Elec Jl—Apr., 08. 3 figs. 8000 w. 20c. Alternating-current overload—polyphase: inverse time element action.

The Protection of Electric Circuits and Apparatus from Lightning and Similar Disturbances. R. P. Jackson. Elec Jl—Apr., 08. 6 figs. 3800 w. 20c. Gives directions for specifying lightning arresters and choke coils.

Swiss High-Tension Transmission.

The Engleberg-Lucerne 25,000-Volt Overhead Transmission. Elec Engg—Mar. 12, 08. 5 figs. 1400 w. 40c. Gives a description of the high-tension transmission lines and sub-stations belonging to this company.

Voltages for Economical Transmission.

Distribution Voltage for Central Stations. J. E. Fries. West Elecn—Apr. 4, 08. 4 figs. 3700 w. 20c. A paper read before the Toronto Branch of the American Institute of Electrical Engineers, Mar. 13, 08.

Economical Pressures for Power Transmission by Underground Cables. J. B. Sparks. Elec Engg—Apr. 2, 08. 4 figs. 2100 w. 40c.

Wiring Rules.

Comparing German and English Wiring Rules. W. P. Steinthal. Elec. Engg—Mar. 26, 08. 1600 w. 40c. Abstract of a paper before the Leeds Local Section of the Institution of Electrical Engineers.

MISCELLANEOUS.

Bureau of Standards: Value to Electrical Industry.

The National Bureau of Standards: The Service that It May Render to Electrical Engineers and Central-Station Companies. Joseph B. Baker. Elec Wld—Apr. 4, 08. 3 figs. 3800 w. 20c.

Copper and Electrical Industry.

Is Copper Essential to the Electrical Industry? H. M. Hobart. Cass Mag—Apr., 08. 1700 w. 40c.

Paper Manufacture, Electric Power in.

The Application of Electric Power to Pulp and Paper Mills. LeRoy M. Harvey. Eng Rec—Mar. 14, 08. 4000 w. 20c.

Plants, Effects of Electricity on.

The Effect of Electricity Upon Plants. J. H. Priestley. Elec Engg—Mar. 26, 08. 5000 w. 40c. Abstract of paper before the Proceedings of the Naturalists' Society.

Porto Rico, Electrical Developments in.

Electrical Developments in Porto Rico. Elec Wld—Mar. 28, 08. 6 figs. 1500 w. 20c.

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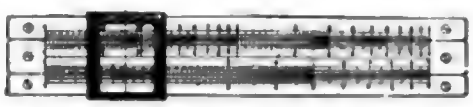

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INDUSTRIAL TECHNOLOGY

Gas Engineering.

A New Carbonic Acid Gas Indicator. Charles D. Robison. Prog Age—Mar. 16, 08. 1 fig. 1000 w. 20c. Paper read before the American Gas Institute, Washington D. C., Oct. 16, 08. Describes a new apparatus for use in connection with water-gas generators.

Gas Lighting in the Factory. T. J. Litle. Prog Age—Mar. 16, 08. 6 figs. 3600 w. 20c. Paper read before the Natl. Commercial Gas Assn., New York, Jan. 8-10, 08. Shows the uses and advantages of the inverted gas mantle and its economy over other methods of illumination.

Readiness-to-Serve Cost of Gas Supply. W. H. Gardiner. Prog Age—Mar. 16, 08. 1 fig. 3000 w. 20c. Paper read before the New England Assn. of Gas Engineers, Boston, Feb. 19-20, 08. Discusses, with calculation, the proportion of the price charged for gas, which is due to investment, over and above that part actually due to manufacture and delivery.

Retort House Practice. W. E. Hartman. Am Gas Lt Jl—Apr. 6, 08. 1 fig. 6000 w. 20c. Paper read at the fourth annual meeting, Illinois Gas Association.

The Behavior of Gas Pipes Under Pressure. A. Petsch. Jl f Gasbel—Mar. 14, 08. 6 figs. 1800 w. 60c.

The Disposal of Coal Tar. Carroll Miller. Am Gas Lt Jl—Mar. 23, 08. 1600 w. 20c. Paper read before the New England Association of Gas Engineers. Shows the value of tar as a by-product to both the gas and coke industries.

The Roger Incandescent Gas Lamp. H. Guérin. Génie Civil—Mar. 21, 08. 3 figs. 1500 w. 60c. Describes a lamp operating with vaporized gasoline and used by a number of French railways for yard and station lighting.

Working Standards of Light and Their Use in the Photometry of Gas. Charles A. Bond. Jl Fklin Inst—Mar., 08. 4 figs. 7500 w. 40c. Paper read before the Franklin Institute, Jan. 9, 08. Deals with several standards generally used in this country, and favoring the Pentane lamp.

Gas-Firing.

Gas-Firing. Ernest Schmatolla. Brit Clay Wkr—Mar., 08. 19 figs. 3400 w. 40c. An address on gas-firing delivered before the English Ceramic Society in Feb.

Glue.

Some Phases of Glue Selection. E. L. Fernbach. Wood Craft—Apr., 08. 3000 w. 20c.

Lime-Burning, Heat Calculations in.

Calculating the Heat Balance of Lime Kilns. Robert Schorr. Eng & Min Jl—Mar. 21, 08. 2400 w. 20c. Gives data of combustion of coal, wood, oil and producer gas for use in calculating the efficiency of direct and gas-fired lime kilns.

Shellac.

Further Notes on Shellac. Dr. H. Endeman. Jl Fklin Inst—Mar., 08. 2100 w. 40c. Additions to a paper published in Oct., 07, number of the Journal.

MARINE ENGINEERING

Battleships.

On the Size of Battleships. Sidney G. Koon. Eng Mag—Apr., 08. 2000 w. 40c. An analysis showing the great sacrifice in efficiency which must be made where the size of the battleship is reduced.

Speed in Battleship Construction. Lieut. A. C. Dewar. Inter Mar Engg—Apr., 08. 2400 w. 40c. From the United Service Magazine.

The Relative Values of Warships. C. T. Brady, Jr. Inter Mar Engg—Apr., 08. 1 fig. 1600 w. 40c.

Diesel Ship Engines.

Diesel Oil Engines for Ship Propulsion. F. E. Junge. Power—Mar. 24, 08. 3 figs. 2900 w. 20c. Gives results of tests of the latest type of high-speed Diesel engine, built at the Augsburg Works, Germany, especially for marine service.

Form of High-Speed Ships.

The Form of High-Speed Ships. A. E. Long. Ship Wld—Mar. 18, 08. 9 figs. 3100 w. 40c. From a paper read before the North-East Coast Institution of Engineers and Shipbuilders at Newcastle-on-Tyne, Feb. 21, 08.

Heating and Ventilation of Ships.

The Heating and Ventilating of Ships. Sydney F. Walker. Inter Mar Engg—Apr., 08. 3 figs. 2000 w. 40c. Describes methods of heating by steam.

Lubrication of Marine Machinery.

International Lubrication of Marine Machinery. Lieut. H. C. Dinger. Inter Mar Engg—Apr., 08. 2100 w. 40c.

Marine Engine Lubrication. Inter Mar Engg—Apr., 08. 4100 w. 40c. Discusses non-fluids, petroleum and animal greases, and flake graphite.

Marine Boilers.

Comparison of Rules for Calculating the Strength of Steam Boilers. Boiler Mkr—Apr., 08. 2500 w. 20c. Compares results obtained from the use of U. S., Lloyd's, Board of Trade, British Corporation and Bureau Veritas rules, with critical comment.

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THE INLAND PUBLISHING CO., Cedarwood, Ind.

Estimating the Cost of a Small Scotch Boiler. James Crombie. Boiler Mkr—Apr., 08. 1 fig. 3200 w. 20c. Gives an estimate of the cost of building a 42x84-in. marine boiler capable of carrying 125 lbs. working pressure.

Some Remarks on the Design, Construction and Working of the Marine Boiler. Richard Hirst. Boiler Mkr—Apr., 08. 2400 w. 20c. Paper read before the Mersey Foremen Boilermakers' and Iron Shipbuilders' Association, Liverpool, England.

Naval Base, Firth of Forth.

The New Naval Establishment at Rosyth. Engg—Mar. 13, 08. 1 fig. 500 w. 40c. Gives a chart to illustrate the scheme prepared by the Works Department of the Admiralty, for the establishment of a naval base at Rosyth, on the Firth of Forth.

Screw Propellers.

Model Propeller Experiments. Engr (Lond)—Apr. 3, 08. 6 figs. 3000 w. 40c. Describes experiments carried out by Prof. Flamm, of the Technical High School, Berlin.

The Screw Propeller. A. E. Seaton. Mar Engr—Apr., 08. 3400 w. 40c. XVII.—Number of Blades.

Vibrations on Board Ship.

Vibrations on Board Ship. Engg—Mar. 13, 08. 4 figs. 1100 w. 40c. Describes apparatus for indicating the extent of vibrations due to the use of explosion engines for ship propulsion.

MECHANICAL ENGINEERING

AIR MACHINERY.

Air Compressors.

Air-Compressor Plants for East River Tunnels of the Pennsylvania Railway. A. D. Williams, Jr. Engr—Apr. 1, 08. 3 figs. 1600 w. 20c. Describes these plants which are the largest installations of air-compressing machinery for any purpose.

Corliss Inlet Valves on Air Compressors. H. V. Conrad. Power—Apr. 14, 08. 4 figs. 1100 w. 20c. Gives simple directions for setting, with diagrams illustrating the plain and swing-plate forms of Corliss air-valve drive.

Steam Consumption in Air Compressors. Engg-Contr—Apr. 8, 08. 400 w. 20c. Gives tables showing the weight of steam required to compress 100 cu. ft. of free air to various gage pressures.

Air Drills.

Lubrication of Air Drills. Claude T. Rice. Eng & Min Jl—Apr. 11, 08. 2 figs. 1300 w. 20c.

Blower, Impeller Layout for.

Laying Out the Impeller for a Positive Pressure Blower. W. S. Giele. Castings—Mar., 08. 1 fig. 1100 w. 20c.

Drying Appliances.

Drying Appliances. Oscar Nagel. Electrochem & Met Indus—Apr., 08. 12 figs. 1800 w. 40c. Describes fan drying, rotary cylindrical dryers and several vacuum drying systems.

Flow of Gases.

The Measurement of Gas Flow Through Thin Orifices. A. O. Mueller. Z V D I—Feb. 22, 08. 8 figs. 5500 w. 60c. Gives construction coefficients for various conditions, by the use of which the quantity of gas flowing through their orifices may be measured.

Pneumatic Tubes.

Pneumatic Tubes for the Factory. Richard H. Libbey. Ind Mag—Mar., 08. 2 figs. 2100 w. 20c.

FOUNDING.

Core-Ovens.

Core-Ovens—Their Styles and Sizes. B. D. Fuller. Castings—Mar., 08. 1300 w. 20c. A study of designs and dimensions, fuels and flues, etc.

Cost Keeping in Foundry Work.

Cost Keeping in the Foundry. W. L. Churchill. Ir Age—Mar. 19, 08. 1500 w. 20c.

Cupola Practice.

Charging Machines for Cupolas. G. R. Brandon. Ir Age—Mar. 19, 08. 6 figs. 1300 w. 20c. From a paper read before the Pittsburg Foundrymen's Association, Mar. 2, 08.

The Cupola Practice of the Foundry. W. S. Anderson. Castings—Mar., 08. 2500 w. 20c. Paper read at a meeting of the Cincinnati Foundry Foremen's Association.

Malleable Castings.

Malleable Cast Iron. W. H. Hatfield. Ir Age—Apr. 2, 08. 9 figs. 2200 w. 20c. Gives a comparison of "Black Heart" and old process castings. Abstract of paper read before the Institution of Engineers and Shipbuilders in Scotland, Mar. 17, 08.

Malleable Iron Castings: Their Characteristics and Annealing. C. H. Gale. Ind Wld—Apr. 13, 08. 2200 w. 20c.

Manufacture of Malleable Castings by New Crucible Process. E. C. Ongley. Ind Wld—Apr. 13, 08. 1800 w. 20c. Describes process for producing ingot metal and castings by melting wrought iron with carbon. 0.05 to 2.25 per cent., in crucibles placed in a furnace of special construction with natural or forced draft.

In Press

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AND THE
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TABLE OF CONTENTS

STRESSES IN TRUSS BRIDGES

Chapter I.—Types of Truss Bridges.
Chapter II.—Loads and Weights of Bridges.
Chapter III.—Methods for the Calculation of Stresses in Framed Structures.
Chapter IV.—Stresses in Beams.
Chapter V.—Stresses in Highway Bridge Trusses.
Chapter VI.—Stresses in Railway Bridge Trusses.
Chapter VII.—Stresses in Portals and Lateral Systems.
Chapter VIII.—Stresses in Pins, Combined and Eccentric Stresses, Stresses in Rollers, Deflection of Trusses, Camber, etc.
Chapter IX.—The Solutions of 24 Problems in the Calculation of Stresses in Bridge Trusses.

THE DESIGN OF HIGHWAY BRIDGES

Chapter X.—The Design of Short Span Steel Bridges.
Chapter XI.—The Design of High Truss Steel Bridges.
Chapter XII.—The Design of Plate Girder Bridges.
Chapter XIII.—The Design of Truss Members.
Chapter XIV.—The Details of Highway Bridge Members.
Chapter XV.—The Design of Abutments and Piers.
Chapter XVI.—Stresses in Masonry Arches.
Chapter XVII.—Design of Masonry Bridges and Culverts.
Chapter XVIII.—The Design of Timber and Combination Bridges.
Chapter XIX.—The Erection of Highway Bridges.
Chapter XX.—Estimates and Cost of Highway Bridges.

HIGHWAY BRIDGE DETAILS

Chapter XXI.—Estimate of the Weight of a 160 ft. Span Steel Pin-Connected Highway Bridge.
Chapter XXII.—Calculation of the Efficiencies of the Members of a 160 ft. Span Steel Pin-Connected Highway Bridge.
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Production of Malleable Castings.—III. Richard Moldenke. Fdry—Apr., 08. 1 fig. 2300 w. 20c. Discusses the methods of making tests of malleables and their improvement and deterioration in quality.

Molding Methods.

Molding a Cast-Steel Clam-Shell Bucket. H. J. McCaslin. Fdry—Apr., 08. 10 figs. 2,000 w. 20c.

Molding a Heavy Pipe Without a Pattern. W. W. McCarter. Southern Machy—Apr., 08. 7 figs. 2500 w. 20c.

Molding a Large Engine Frame. Paul R. Ramp. Fdry—Apr., 08. 7 figs. 1000 w. 20c. Describes the method used in making a 20-ton casting in a Western foundry, and the use of cope plates.

Molding Drums for Hoisting Engines. Joseph F. Hart. Am Mach—Mar. 19, 08. 14 figs. 1000 w. 20c. Describes and illustrates the sweeps, bars, anchors, spiders, core boxes, etc., used in sweeping and building the molds in green sand or loam.

Ornamental Iron Castings.

Ornamental Gray Iron Castings. H. Cole Estep. Fdry—Apr., 08. 8 figs. 2600 w. 20c. Gives details of practice followed in a new plant in Minneapolis, Minn.

Patterns, Marking and Storage of.

The Marking and Storing of Patterns. John J. Jackson. Castings—Mar., 08. 3 figs. 2000 w. 20c. Suggests a system of symbols for yielding a practical and sufficient classification of live and obsolete drawings, patterns and castings.

Steel Castings.

Converter vs. Small Open-Hearth.—IV. W. M. Carr. Fdry—Apr., 08. 1000 w. 20c. Discusses the disadvantages of the open-hearth furnace for steel casting plants.

The Annealing of Steel Castings. E. H. Oehler. Fdry—Apr., 08. 4 figs. 900 w. 20c. Gives results of the heat treatment of cast steel from the experience of a practical steelmaker.

Vanadium in Foundry Work.

The Practical Application of Vanadium to Steel and Iron. J. Kent Smith. Ir Tr Rev—Apr. 2, 08. 1 fig. 2300 w. 20c.

Vanadium in Steel Castings. E. F. Lake. Am Mach—Apr. 2, 08. 1600 w. 20c. Discusses the properties conferred on steel castings by the addition of vanadium, together with some of the tests made, etc.

HEATING AND VENTILATION.

Boiler Settings, Tests of.

Comparative Tests of Tubular Boiler Settings for Chicago Public Schools. Heat & Vent Mag—Mar., 08. 2600 w. 20c.

Hot-Blast Heating.

An Anemometer and Wind Direction Indicator. Eng Rec—Apr. 11, 08. 1 fig. 1200 w. 20c. Describes the apparatus used in the Hotel St. Regis, New York City, which is heated throughout by the indirect fan-blast system, for adjusting the temperature of the air deliveries and the proportions of the supply volumes to the different sides of the various floors, so as to equalize as nearly as possible the heating effect in all parts of each floor.

Size of Drip Mains for Hot Blast Heaters. (Table.) Charles W. Fortune. Dom Engg—Apr. 11, 08. 20c.

Hot-Blast Heating. Charles L. Hubbard. Dom Engg—Mar. 14, 08. 3 figs. 1200 w. 20c. XXIII.—Temperature Control.

Hot-Water Heating.

The Calculation of Piping Systems for Hot-Water Heating Plants. Gesund Ing—Mar. 14, 08. 7 figs. 4400 w. 40c.

Hot-Water Supply.

Hot Water for Domestic Use. (II & III.) John K. Allen. Dom Engg—Mar. 21, 08. 1 fig. 1400 w. Apr. 4. 1 fig. 1000 w. Each 20c.

House-Heating Plants.

Summer Care of Heating Plants. Dom Engg—Apr. 4, 08. 1500 w. 20c.

Testing Cast-Iron House-Heating Boilers. Wm. Kent. Heat & Vent Mag—Mar., 08. 2400 w. 20c. Paper read Jan. 22, 08, before the Am. Soc. Heat & Vent. Engineers.

Steam Heating.

Back Pressures in a Factory Heating Plant. John C. White. Power—Apr. 14, 08. 1 fig. 3400 w. 20c. Shows that increasing the back pressure adds little to the heating capacity of the plant, while it seriously reduces its efficiency.

Modern Steam Heating Illustrated. B. F. Taber. Dom Engg—Mar. 21, 08. 1 fig. 1100 w. Apr. 4. 1 fig. 900 w. Each 20c. II.—The two-pipe system. III.—Basement arrangements.

Ventilation.

Forced Ventilation in Buildings. K. Brabbée. Z V D I—Feb. 28, 08. 7 figs. 6500 w. 60c.

Heating and Ventilation of the Madison Square Presbyterian Church, New York. Eng Rec—Mar. 14, 08. 5 figs. 5200 w. 20c.

The Operation of a Modern Heating and Ventilating System. Heat & Vent Mag—Mar., 08. 3 figs. 5200 w. 20c. Gives information and instructions on the heating and ventilating of the New York City Public Schools, as published by the New York City Board of Education.

Warming and Ventilation. W. H. Casmey. Heat & Vent Mag—Mar., 08. 7400 w. 20c. From a prize paper read at the Feb., 08, meeting of the British Institution of Heating and Ventilating Engineers.

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Cableways, Cranes, Conveyors.

Hoisting Machinery for the Handling of Materials. T. Kennard Thomson. Eng Mag—Apr., 08. 24 figs. 2700 w. 40c. II.—Cranes, cableways and transporting conveyors.

Cranes.

A 140-Ton Floating Crane. W. Kaemmerer. Z V D I—Feb. 22, 08. 11 figs. 1800 w. 60c.

Five-Ton Electric Overhead Traveling Jib-Crane. Engg—Mar. 20, 08. 1 fig. 1700 w. 40c.

Forty-Ton Revolving Crane. M. Lombard. Génie Civil—Mar. 14, 08. 9 figs. 2000 w. 60c. Describes the principal features of a new installation at the port of La Rochelle—Pallice, France.

The Storage Warehouse of the South German Danube Navigation Co. R. Dub. Z V D I—Mar. 7, 08. 20 figs. 2500 w. 60c. Describes the revolving and traveling cranes used.

Elevators.

Electric Lifts. Elec Engg—Mar. 19, 08. 2800 w. 40c. Résumé of a paper read Mar. 11 by H. D. Wilkinson before the Association of Engineers-in-Charge.

The High-Pressure Hydraulic Elevator. Wm. Baxter, Jr. Power—Mar. 24, 08. 3 figs. 1700 w. Apr. 7. 3 figs. 1200 w. Apr. 14. 5 figs. 1400 w. Each 20c. Mar. 24: Construction and operation of the Otis vertical elevator, including pumps and accumulator. Apr. 7: Main and pilot valves of Otis elevator, and the electrical control. Apr. 14: Valve modifications necessitated by use of magnets; construction and operation of accumulators for high-pressure work.

The Hydraulic Elevator. William Baxter, Jr. Power—Mar. 17, 08. 5 figs. 1900 w. 20c. Discusses features of the Morse & Williams pulling machine; why it has no pilot valve; construction of the carrier rollers and piston; lubrication, etc.

Escalators.

Escalators. Génie Civil—Mar. 21, 08. 8 figs. 800 w. 60c. Describes a number of moving stairway systems now in use.

Ore Handling.

Methods of Handling Ore on the Great Lakes. Charles H. Wright. Min Wld—Apr. 4, 08. 10 figs. 1000 w. 20c.

Spiral Conveyor.

The Problem of the Spiral Conveyor. F. Webster. Machy—Apr., 08. 5 figs. 1200 w. 40c. Describes method for laying out the pattern for the flights, which are punched from sheet-metal.

Winding Machinery.

Dense-Air Winding-Engine for the Consolidated Gold-Fields of South Africa. Engg—Mar. 13, 08. 3900 w. 40c.

Winding-Ropes, Safety-Catches, and Appliances in Mine-Shafts. Engg—Mar. 13, 08. 6 figs. 2800 w. 40c. Concluded.

HYDRAULIC POWER PLANTS.

Centrifugal Pumps.

High-Pressure Centrifugal Pumps. D. Banki. Zeit Oest Ing u Arch—Feb. 28, 08. 29 figs. 1500 w. 80c.

The Action of Centrifugal Pumps and Fans. R. Biel. Z V D I—Mar. 21, 08. 28 figs. 6000 w. Mar. 28. 6500 w. Each 60c. Gives a brief statement of the theory of their action and results obtained from a number of tests.

The Efficiency of Centrifugal Pumps. Tech Sanit—Mar., 08. 6 figs. 3500 w. 80c. Abstract from a discussion of the points to be observed in attaining maximum efficiency; read before the Congress of Engineers of the Lower Rhine.

Flow of Water, Measurement of.

Determination of the Volume of Water Flowing in a Stream. F. M. Berlin. Power—Apr. 14, 08. 2 figs. 1100 w. 20c.

Notes on the Measurement of Flowing Water. Ernest W. Schoder. Cornell Civ Engr—Mar., 08. 7 figs. 3000 w. 40c. Reviews some of the available methods of measurement in order to bring out certain obscure points, as well as to look into the matter of the desirable degrees of accuracy for different cases and also the accuracy practically attainable.

Hydro-Electric Plants.

A Hydro-Electric Development in Utah. Eng Rec—Mar. 14, 08. 4 figs. 3400 w. 20c. Describes the Battle Creek plant of the Telluride Power Co., near Provo.

Construction Features of the Hydro-Electric Plant of the Rockingham, N. C., Power Co. J. S. Viehe. Eng Rec—Apr. 4, 08. 6 figs. 2600 w. 40c.

Hydraulic and Electrical Works of the Lewiston-Clarkston Co., Clarkston, Wash. Ry & Engg Rev—Mar. 14, 08. 7 figs. 800 w. 20c. Describes this recently completed extensive engineering work in hydro-electric plants, dam and pipe-line construction, for purposes of power development, irrigation and for municipal use.

Power Development at Priest Rapids on the Columbia River, Ore. C. L. Creelman. Eng Rec—Apr. 4, 08. 2 figs. 900 w. 40c. Describes work consisting of a canal, an embankment about 2 miles long, a power house with a present capacity of 2,600 HP. with arrangements for an additional 5,000 HP., a dam, 450 ft. long, across the channel just below the diversion point, and a system of gates in the canal midway between the intake and power house.

Penstock.

Penstock with Reinforced-Concrete Lining at the Northern Aluminum Works, Shawinigan Falls. Eng Rec—Apr. 4, 08. 6 figs. 4000 w. 40c.

Power Costs in Ontario.

The Cost of Power in Ontario. Can Mfr—Apr. 3, 08. 6000 w. 20c. Extracts from the report by the Hydro-Electric Power

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Commission of Ontario on the cost of power production through the agency of producer gas plants and other prime movers under the conditions obtaining in the Province of Ontario.

Pumping Machinery.

Modern Hydraulic Machinery. Carl Wigtel. Cass Mag—Apr., 08. 16 figs. 1700 w. 40c. Describes recent pumps, accumulators and pressure-generating apparatus.

Modern Pumping and Hydraulic Machinery. Edward Butler. Mech Engr—Mar. 20, 08. 5 figs. 4200 w. 40c. XXXI.—Variable delivery pumps.

A High-Head Reaction Turbine Installation. Eng Rec—Mar. 21, 08. 3 figs. 2600 w. 20c. Describes a 9,700-HP. hydraulic reaction turbine at Centerville, Cal., designed to operate under an effective head of 550 ft.

INTERNAL-COMBUSTION ENGINES.

Calorimeter, Gas.

A Simple Continuous Gas Calorimeter. Prof. C. E. Lucke. Proc Am Soc Mech Engr—Apr., 08. 6 figs. 3000 w. 80c. Paper presented at the first meeting of the Gas Power Section of the A. S. M. E., Feb. 11, 08. Describes an arrangement of Junkers' apparatus.

Combustion.

Combustion in Gas Engines. Z V D I—Apr. 4, 08. 14 figs. 7500 w. 60c. Gives results of experiments carried out at the Technical High School, Dantzig.

Gas-engine Research at Birmingham University. W. H. Booth. Power—Mar 24, 08. 2100 w. 20c. A critical résumé of Prof. Burstall's recent report to the Institution of Mechanical Engineers.

Cost of Gas Power.

The Approximate Cost of Gas Power. M. P. Cleghorn. Power—Apr. 7, 08. 16 figs. 1300 w. 20c. Gives curves showing computation of continuous expenses, cost of jacket water, fixed charges and relative continuous costs.

Gas Engines, Design and Testing of.

High-Power Gas Engines for Mining Service. Frank C. Perkins. Min Wld—Apr. 4, 08. 2 figs. 700 w. 20c.

Standard Designs and Construction of Large Gas Engines.—I. F. E. Junge. Ir Tr Rev—Mar. 26, 08. 6 figs. 3400 w. 20c. Discusses economy, combustion, cycles, governing arrangement and accessibility of parts, engine frames, etc.

Test of a Small 15-HP. Suction Gas Producer Plant. Eng Rec—Mar. 28, 08. 1500 w. 20c.

The Testing of Small Gas Engines. Pract Engr (Lond.)—Mar. 13, 08. 1500 w. 40c. Gives instructions for carrying out such tests.

Gas Producers.

Gas Producers for Lean Gas. M. Letombe. Mem. Soc. Ing. Civ., France. 60,000 w. 14 figs. $1.20. Extended discussion on gas producers used for driving gas motors as well as for industrial furnaces.

New Gas Producer Building, Pennsylvania Steel Works. Eng Rec—Mar. 21, 08. 7 figs. 2500 w. 20c. Describes a producer house with a capacity of about 1,460,000 cu. ft. per hour for supplying five new 75-ton open-hearth steel furnaces.

Gas Turbine.

Recent Developments in the Gas Turbine. Alfred Barbezat. Cass Mag—Apr., 08. 3 figs. 1700 w. 40c. Describes the advances made in the past year.

Guarantees, of Engines and Producers.

Gas Engine and Producer Guarantees. Prof. C. E. Lucke. Proc A S M E—Apr., 08. 3000 w. 80c. Paper presented at the first meeting of the Gas Power Section of the A. S. M. E., Feb. 11, 08. Gives many forms of guarantees, clipped from some old contracts, to direct attention to the need for an accepted mode of procedure and interpretation of terms.

Heating Value of Gases.

Computation of Heating Value of Gases. H. B. MacFarland. Gas Power—Mar., 08. 3300 w. 20c.

MACHINE PARTS.

Belting.

Power Losses in High-Speed Belts. A. S. Dickinson. Am Mach—Apr. 2, 08. 800 w. 20c.

The Design of Belt Drives.—I. George P. Pearce. Southern Machy—Apr., 08. 4 figs. 3500 w. 20c.

Cross-Heads, Connecting-Rods, etc.

Machine Elements. C. Volk. Z V D I—Mar. 28, 08. 63 figs. 2800 w. 60c. Gives numerous sketches of various forms of cross-heads, cross-head pins, connecting-rod ends and brasses, nut locks, etc.

Stub-Tooth Gears.

The Stub-Tooth Gear. Machy—Apr., 08. 7 figs. 1300 w. 40c. From a pamphlet published by the Fellows Gear Shaper Co., Springfield, Vt. Discusses the advantages of the "stub-tooth" gear, a form of shortened and strengthened involute tooth cut with stub-tooth cutters.

MATERIALS.

Alloys for Bearings.

A New Bearing Metal. Lothar Sempell. Power—Mar. 24, 08. 1 fig. 1700 w. 20c. Gives details regarding an aluminum-copper alloy having better wearing properties than a certain highly regarded tin-antimony-copper white metal and costing but one-sixth as much.

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History and Development of Alloys for Railroad Bearings. G. H. Clamer. Can Machy—Apr., 08. 3000 w. 20c. Presented at the annual meeting of the American Society for Testing Materials. Discusses influences causing the development, giving records of experiments performed by several investigators and the composition of many standard alloys.

The Manufacture of Ingot Brass. Mech Engr—Mar. 13, 08. 2200 w. 40c. Reprint of an article in "The Brass World."

White Brass and White Bronze. Castings—Mar., 08. 1300 w. 20c. Gives comparisons of various new and old formulas, some recent tests of alloys, and a survey of their use.

Cast Iron, Growth of.

The Growth of Cast Iron by Heating. A. E. Outerbridge. Am Mach—Mar. 19, 08. 1200 w. 20c.

Hardness Tester for Iron and Steel.

The Schuchardt & Schütte Steel Hardness Tester. Ir Age—Apr. 9, 08. 5 figs. 3000 w. 20c. Describes an electro-magnetic instrument for determining carbon content, hardness, etc., of iron and steel.

Lubricants.

The Chemical and Physical Testing of Lubricants.—I. J. J. Morgan. Pract Engr (Lond.)—Mar. 30, 08. 2 figs. 2400 w. 40c.

Steel.

The Effect of Work and Time on the Properties of Mild Steel and Iron. John H. Heck. Boiler Mkr—Apr., 08. 4 figs. 3100 w. 20c. Paper read before the Northeast Coast Institute of Engineers and Shipbuilders, at Newcastle-upon-Tyne, England, Nov. 29, 07.

MECHANICAL DRAFTING.

Large Drawings.

Making Six by Ten-Foot Drawings. H. F. Noyes. Am Mach—Mar. 19, 08. 1 fig. 600 w. 20c.

Perspective.

Perspective. S. M. Turrill. Cornell Civ Engr—Mar., 08. 7 figs. 5500 w. 40c. Gives definitions and works out illustrative problems in parallel and angular perspective, the perspective of curves and of shadows.

MECHANICS.

Helical Governor Springs.

The Deflection of Rotating Helical Governor Springs. J. Zvonicek. Z V D I—Feb. 22, 08. 17 figs. 4000 w. 60c. Gives formulas and illustrative calculations.

Stresses in Links, Eyes, etc.

The Calculations of Curved Bars. A. Bauman. Z D V I—Feb. 28. 08. 1 fig. 8000 w. Mar. 7, 7 figs. 6000 w. Each 60c. Gives mathematical analysis of the stresses in links, eyes, staples, etc.

Jigs and Fixtures.

Jigs and Fixtures. E. Morin. Machy—Apr., 08. 4 figs. 4200 w. 40c. Discusses the fundamental principles in jig design.

Toolmaking in a Large Manufacturing Plant. H. C. Barnes. Am Mach—Apr. 9, 08. 5 figs. 4000 w. 20c. Discusses the economical production of jigs, dies and other appliances made in large quantities by various toolroom departments.

Mandrel.

Making a Novel Gun-Barrel Mandrel. Eugene C. Peck. Am Mach—Mar. 19, 08. 3 figs. 900 w. 20c.

Milling Machines.

Purchasing Milling Machines by Power. P. V. Vernon. Engr (Lond.)—Mar. 13, 08. 1800 w. 40c. States how the question of power as applied to milling machines should be regarded by the purchaser.

Motor Drive.

The Application of Motors to Machine Tools. Dexter S. Kimball. Sibley Jl—Mar., 08. 1 fig. 6000 w. 40c. From the Proceedings of the Combined Electrical and Mechanical Engineering Societies of Cornell University.

Painting of Machinery.

Filling and Painting Machine Tools. H. J. Huddleston. Machy—Apr., 08. 2 figs. 1000 w. 40c.

Planers.

Some Planing Machine History. T. R. Shaw. Mech Engr—Mar. 13, 08. 7 figs. 2100 w. 40c. Paper read before the Coventry Engineering Society. Concluded.

Punch.

A Hand Punch for Making Rivet Holes. Eng News—Apr. 9, 08. 1 fig. 700 w. 20c. Gives proportions for a punch capable of punching a 13/16-in. hole in ⅝-in. steel plate.

Screw Machine Work, Time Required for.

The Time Required for Machine Work.—II. Fred H. Colvin. Am Mach—Mar. 19, 08. 6 figs. 1100 w. Apr. 2. 6 figs. 1200 w. Each 20c. Gives examples of automatic screw-machine work of assistance in estimating or in selecting the best types of machines.

Spiral Cutters.

A Study in Spirals. Walter Gribben. Machy—Apr., 08. 3 figs. 1800 w. 40c. Shows the departure from the true form of the cutter, due to faulty table setting.

Steel and Its Uses.

Steel and Its Uses. Edmund F. Lake. Am Mach—Mar. 26, 08. 38 figs. 40,000 w. 20c. A series of articles filling 40 pages (40,000 w., 38 figs.) of the issue, and forming a brief and up-to-date treatise on furnaces for converting iron into steel, ingredients and materials of steel, heat treatment, properties and methods of testing steel, rolling, forging, welding, casting and machining and their effect on strength and grain, etc., etc.

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METAL WORKING.

Boring.

Boring Bars for Turbine Castings. T. M. Lowthian. Am. Mach—Mar. 26, 08. 4 figs. 800 w. 20c.

Special Features of Recent Boring Mills. Am Mach—Mar. 19, 08. 5 figs. 800 w. 20c.

Die, Sectional.

A Remarkable Section Die. Am Mach—Apr. 11, 08. 1 fig. 500 w. 20c. Describes a die constructed for making a large number of openings in sheet steel, and containing nearly 70 parts, including the series of clamp blocks along the sides of the die sections.

Drill.

A Multiple-Spindle Sub-Drill. F. H. Stead. Am Mach—Mar. 19, 08. 800 w. 20c.

Forging.

Armor-Plate Forging and Machining at the Bethlehem Steel Works. Machy—Apr., 08. 4 figs. 2100 w. 40c.

Gear Cutting.

Cutting Racks with a Hub. Am Mach—Apr. 11, 08. 4 figs. 300 w. 20c.

Derivation of Formula for Determining Spur-Gear Cutter Number for Spiral Gears. H. W. Henes. Machy—Apr., 08. 1 fig. 1400 w. 40c.

Gear-Cutting Machinery.—IV. Ralph H. Flanders. Machy—Apr., 08. 19 figs. 7000 w. 40c. Describes rack cutters and machines for forming worm, spiral and herringbone gears.

Grinding.

A New Type of Grinding Machine. Am Mach—Mar. 19, 08. 5 figs. 1600 w. 20c. Describes machine using emery cloth belts in a new way to produce finished surfaces at a very low cost.

Grinding and Grinding Machines. Carl Olson. Machy—Apr., 08. 4 figs. 5200 w. 40c. Gives data on wheel speeds and cuts, and instructions for using grinding machines.

Grinding vs. Cutting by Emery Wheels. C. H. Norton. Am Mach—Mar. 26, 08. 12 figs. 1700 w. 20c. Gives a comparison of conditions, power, speeds and time necessary to remove metal by grinding under normal and abnormal conditions.

Taper Gage.

A Gage for Use in Producing Accurate Tapers. C. C. Stutz. Am Mach—Mar. 26, 08. 9 figs. 2000 w. 20c. Describes the measuring of tapers or establishing their proportions by a gage with adjustable jaws set by a pair of disks.

Taps.

Taper Taps. Erik Oberg. Machy—Apr., 08. 7 figs. 3000 w. 40c. Gives data on pipe hobs, boiler taps and blacksmith taps.

Tempering, etc.

Chloride of Barium for Hardening. O. M. Becker. Am Mach—Apr. 2, 08. 1 fig. 2600 w. 20c. States the proper style of furnace to use, how the chemical should be handled and its effect when hardening steel tools.

The Heat Treatment of Steel. E. R. Markham. Southern Machy—Apr., 08. 2200 w. 20c. II.—Selection and testing of steel.

Modern Methods of Temperature Measurement. Pract Engr (Lond.)—Mar. 27, 08. 9 figs. 2800 w. Apr. 3. 4 figs. 1200 w. Each 40c. Describes the construction and working of the various types of thermometers and pyrometers used in commercial work.

Tool-Room Systems.

Tool Rooms. C. L. Goodrich. Ir Age—Apr. 2, 08. 2300 w. 20c. Enumerates most of the common tools and the number of each which answer for a department of about 75 men building small automatic and hand turret lathes and similar work. Also describes several tool-keeping systems.

REFRIGERATION.

Absorption System.

Advantages of Absorption Refrigerating Machines. Heyward Cochran. Cold Stor & Ice Jl—Mar., 08. 1 fig. 4000 w. 20c. Paper read before the Western Ice Mfrs. Exchange, Kansas City, Mar. 5-7, 08.

Compressor Test.

Test of Compressor. Charles E. Lucke. Ice & Refrig—Apr., 08. 4 figs. 5700 w. 40c. Gives details of tests on a 50-ton De La Vergne oil compressor, with tables showing speeds, pressures, temperatures and steam used per ton refrigeration.

Mechanical Refrigeration.

Mechanical Refrigeration.—I. M. G. Anderson. Mech Mld—Mar. 20, 08. 6 figs. 1600 w. 40c. Paper read before the Manchester Association of Engineers. Discusses briefly the principles on which refrigerating machines are based, and the special apparatus used for carrying out tests in a methodical way.

Refrigeration with Compressed Air.

Practical Refrigeration with a Compressed-Air Motor. Comp Air—Apr., 08. 8500 w. 20c. Describes an air motor in a Paris brewery, the public compressed-air service being used to drive the motor for electric lighting purposes, and the exhaust being used for refrigerating with such success that the power and light service costs practically nothing.

Remodeled Plant.

How a Refrigerating Plant Was Remodeled. Warren O. Rogers. Power—Mar. 24, 08. 3 figs. 1000 w. 20c. Describes the sub-station of gas engines for the electric equipment of a packing house resulting in marked improvement in efficiency.

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SHOPS AND BUILDINGS.

Engineering Works and Machine Shops.

The Hungarian State Engineering Works. —I. Engr (Lond.)—Mar. 27, 08. 6 figs. 4300 w. 40c. Describes works at Budapest for the construction of steel bridges, all kinds of structural work, boilers, engines, locomotives, agricultural machinery, oil motors, steam and electric railway motors, water mains, pipes, etc.

The New Works of Hans Renold, Ltd. J. W. Carroll. Am Mach—Mar. 19, 08. 7 figs. 1400 w. 20c. Describes methods whereby the details of equipment of the Manchester (Eng.) factory are effectively worked out on a unit interchangeable system.

The Works of Sir William Arrol & Co., Ltd. Engg—Mar. 20, 08. 13 figs. 400 w. 40c. Illustrated description of a large bridge shop in Glasgow.

Pattern Shop, System for.

A Practical Pattern Shop System. Oscar E. Perrigo. Fdry—Apr., 08. 6 figs. 2900 w. 20c. Describes a simple method of recording patterns, employing the use of cards of distinctive colors.

Wooden Frame Shop.

A Large Wooden Frame Shop. Eng Rec —Apr. 11, 08. 2 figs. 700 w. 20c.

STEAM POWER PLANTS.

Automatic Steam-Pipe Valves.

Isolating Valves. G. W. Koehler. Z V D I—Mar. 14, 08. 35 figs. 6500 w. 60c. Describes a large number of steam-pipe valves which automatically close when a rupture takes place in the pipe beyond the valve.

Boiler.

A Welded Boiler. Charles F. Bennett. Boiler-Mkr—Apr., 08. 2 figs. 1500 w. 20c. Describes methods used on a 23x48-in. tubular boiler using the oxy-acetylene blowpipe.

Coal Calorimeter.

Radiation Correction for the Coal Calorimeter. Ernest H. Peabody. Stev Inst Ind—Jan., 08. 1 fig. 2300 w. 60c. Suggests a new and simple formula for use in this connection.

Cost of Power and Power Plants.

Cost of Power Production. I. V. Robinson. El Rev (Lond.)—Mar. 13, 08. 1300 w. 40c.

Graphical Presentation of Power-plant Costs. W. C. Way. Power—Mar. 17, 08. 6 figs. 1000 w. 20c. Gives curves showing average working conditions, with capital costs compiled from information supplied by manufacturers.

Some Interesting Data on Steam and Gas. J. H. Alexander. Engr—Apr. 1, 08. 2800 w. 20c. Gives comparative costs and efficiencies of a steam and a gas engine plant.

Draft.

Does It Pay to Equip a Boiler Room with CO_2 Recorders? H. J. Westover. Power—Apr. 7, 08. 1 fig. 1500 w. 20c.

Recording Draught-Gauge. Engg—Mar. 13, 08. 2 figs. 900 w. 40c. Describes an instrument for recording continuously the suction of a chimney or a flue, measured in inches of water.

Regulation of the Draft of Steam-Boiler Furnaces. W. H. Wakeman. Elec Wld—Apr. 4, 08. 4 figs. 2000 w. 20c.

Feed-Water Treatment.

A New Method for the Purification of Water. Inter Mar Engg—Apr., 08. 1300 w. 40c. Describes a new process of water purification of carbonate of barium, by virtue of which certain evil effects due to chemical occurrences in other methods are avoided.

Apparatus for Preventing the Formation of Coherent Scale in Boiler. M. Golsdorf. Eng News—Apr. 9, 08. 3 figs. 700 w. 20c. From the bulletin of the International Railway Congress Association for Oct., 07.

Boiler Feed-Water Treatment. Ir Age—Mar. 19, 08. 2 figs. 1800 w. 20c. Describes a water softening and purifying system installed by the Woodward Iron Co., Woodward, Ala.

Fuel.

Burning Sawdust, Tan-bark and Mill Refuse. Power—Apr. 7, 08. 5 figs. 1800 w. 20c. Gives views of a number of correspondents as to the best methods of handling this class of material, and the type of furnace required.

Government Fuel-Testing Plant at Denver, Colo. G. R. Delameter. Min & Min—Apr., 08. 11 figs. 3100 w. 20c. Describes the methods employed in making tests and the special apparatus used.

Oil Filter.

One Barrel of Oil Per Year. George H. Kellogg. Power—Mar. 24, 08. 3 figs. 800 w. 20c. Describes a home-made wick filter used in effecting this result in connection with a 400-HP. engine.

Piston Speeds.

Piston Speed and Steam-Engine Economy. Prof. R. L. Weighton. Mech Engr—Apr. 3, 08. 5 figs. 4000 w. 40c. Paper read before the North-East Coast Institution of Engineers and Shipbuilders, Mar. 20, 08.

Smoke Prevention.

Smoke Prevention Experiences Told by a Well-known Expert. John W. Krause. Ind Wld—Apr. 13, 08. 8500 w. 20c. An extended article by the Supervising Engineer of the city of Cleveland.

Steam Formation.

The Formation of Steam. R. H. Smith. Engr (Lond.)—Mar. 27, 08. 3400 w. 40c. A study of the physical questions involved.

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Determining Sizes of Steam Mains and Risers. Engg-Contr—Mar. 25, 08. 20c. (Table).

Steam Piping for Industrial Plants. W. E. Housman. Eng Mag—Apr., 08. 14 figs. 4400 w. 40c. Deals principally with medium-sized plants designed for moderate steam pressures, also giving data on the distribution of steam underground in mining operations.

Steam Power Plants.

New Generating Station of the Merchants' Power Co., Memphis, Tenn. Eng Rec—Apr. 11, 08. 2 figs. 1900 w. 20c.

The Central Power Station of the De Beers Consolidated Mines, Ltd., Kimberly, South Africa. Percy A. Robbins. Bull Am Inst Min Engrs—Mar., 08. 11 figs. 10,000 w. $2. Paper read at the New York meeting of the A. I. M. E., Feb., 08.

Steam Turbines.

Auxiliaries for Steam Turbines. Thomas Franklin. Power—Mar. 17, 08. 4 figs. 3400 w. 20c. Discusses their adaptation to the service, with especial reference to the points to be noted in their preparation for testing.

Design of a 400-Kilowatt Reaction Turbine. Henry F. Schmidt. Engr—Apr. 1, 08. 5 figs. 4700 w. 20c. Discusses the forms of blades and spacers, and methods of insertion.

Exhaust Steam Turbines.—I. Engr (Lond.)—Mar. 13, 08. 3 figs. 1900 w. 40c. A summarized translation of a paper read by Prof. A. Rateau before the Society of Belgian Engineers, Feb., 07.

Extension of Generating Plant at Wolverhampton. Elec Engg—Mar. 19, 08. 7 figs. 2700 w. 40c. Describes the new turbo-generator installation for power supply.

Steam-Turbine Construction.—VII. T. Franklin. Mech Wld—Mar. 27, 08. 10 figs. 900 w. 40c.

Steam-Turbine Engineering. Mech Engr—Mar. 13, 08. 2200 w. 40c. Abstract of a paper before the Manchester Association of Engineers by S. L. Pearce; deals with the elementary principles which form the basis of turbine design and the development of the many types of the modern steam turbine.

Steam-Turbine Engineering. S. L. Pearce. Pract Engr (Lond.)—Mar. 27, 08. 3000 w. 40c. Concluded.

Steam-Turbine Power and Transmission Plant of the Moctezuma Copper Co., Nacozari, Sonora, Mexico. John Langton and Charles Legrand. West Elecn—Apr. 11, 08. 2 figs. 4600 w. 20c. A paper read before the Electrical Section of the Canadian Society of Civil Engineers at Montreal, Mar. 5, 08.

Testing a Steam Turbine. Thomas Franklin. Power—Mar. 24, 08. 2 figs. 3200 w. 20c. Describes methods used when a surface condenser is available; weighing and measuring tanks; test loads; method of starting; gland seal, steam or water, etc.

The Principles of Steam-Turbine Buckets. William E. Snow. Power—Mar. 17, 08. 18 figs. 2000 w. 20c. Compares the different types of bucket and gives a simple graphical explanation of their various forms and functions.

The Question of Steam-Turbine Safety Governors—II. Pract Engr (Lond.)—Mar. 13, 08. 5 figs. 1200 w. 40c. Concluded.

The Steam Path of the Turbine. Power—Mar. 24, 08. 4 figs. 3700 w. 20c. Report of the discussion of Dr. Steinmetz's A. S. M. E. paper on this subject, in which disagreement was manifested as to how steam expands in a nozzle, the energy developed and the velocity.

Superheated Steam.

Hot Gas Reheaters. Power—Apr. 14, 08. 3 figs. 700 w. 20c. Describes a reheater in which the boiler gases pass through the tubes and the steam around them, the steam being superheated about 50° F., resulting in a saving of 6%.

Investigations of the Pressure and Temperature Drop of Saturated and Superheated Steam Flowing in Pipes.—I. C. Eberle. Z V D I—Mar. 28, 08. 19 figs. 6500 w. Apr. 4. 11 figs. 9000 w. Each 60c.

"Is the Game Worth the Candle?" Power—Mar. 24, 08. 1200 w. 20c. Communication from E. H. Foster, citing a number of instances where the use of superheated steam has effected marked saving in fuel consumption.

The Specific Heat of Superheated Steam. R. C. H. Heck. Power—Mar. 24, 08. 1 fig. 1300 w. 20c. A reply to Prof. S. A. Reeve's recent criticism of the experiments of Knoblauch and Jakob upon the specific heat of superheated steam under constant pressure, in which their method of calculation is questioned.

Valve Setting.

How to Set the Valves of a Putnam Engine. F. L. Johnson. Power—Apr. 14, 08. 7 figs. 700 w. 20c. Points out the distinctive features of the valve-gear and gives plain directions for setting the valves with approximate accuracy.

Valve Setting for the Greene-Wheelock Engine. Hubert L. Collins. Power—Apr. 7, 08. 15 figs. 2500 w. 20c. Describes the Wheelock valve-gear, with the Greene and Hill modifications, and gives detailed directions for adjusting and setting it.

WOODWORKING.

Saw Guards, Gages, etc.

Saw Guards, Shaft Couplings and Fine Woodworking. James F. Hobart. Wood Craft—Apr., 08. 7 figs. 1700 w. 20c. Describes a simple scheme of saw protection, the secure connection of shafting in woodworking plants and the novel use of a system of gages borrowed from another trade.

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Condition of the Coal Briquetting Industry in the United States. Am Gas Lt Jl—Mar. 30, 08. 6400 w. 20c. Concluded.

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Smelting.

Pyritic Smelting and Continuous Converting. O. S. Garretson. Eng & Min Jl—Apr. 11, 08. 2500 w. 20c.

Smelter Dust Flue and Stack. Min & Min—Apr., 08. 2 figs. 1000 w. 20c. Describes the novel features of construction used in the plant of the Southwest Smelting & Refining Co.

The New Balaklala Smelter, of the Balaklala Consolidated Copper Co. J. L. Mauch. Min & Min—Apr., 08. 5 figs. 5800 w. 20c. Describes the proposed sampling and smelting operations.

Slime Treatment.

Electrometallurgical Treatment of Copper Slimes. Don Hollis, F. P. Lannon, Theo. W. Quayle and P. D. Grommon. Bull Colo Sch Min—Jan., 08. 8000 w. 60c. Describes the processes employed for such work and gives cost data on treatment.

GOLD.

Cyaniding.

Cyaniding Cripple Creek Ores. F. L. Barker. Min & Min—Apr., 08. 3100 w. 40c. Discusses the cost of treatment, rates of freight and analyses of ores, describes the Isabella and the Wild Horse Mills.

Electro-Cyanide Process. Douglas Lay. Eng & Min Jl—Apr. 11, 08. 2800 w. 20c. Discusses the method of precipitating the precious metals from cyanide solutions by electrolysis of muddy solutions.

Milling and Cyaniding Methods in Mexican Camp. Mark R. Lamb. Min Wld—Apr. 11, 08. 6 figs. 2600 w. 20c.

Notes on Preliminary Cyanidation Work. H. F. A. Riebling. Min & Min (Denver)—Mar. 20, 08. 1800 w. 20c. Extract from the Western Chem. & Met.

Present Cyanide Practice in Mexico. Mark R. Lamb. Eng & Min Jl—Apr. 4, 08. 11 figs. 5100 w. 20c.

Precipitation by Zinc Dust.

Precipitation by Zinc Dust at the Homestead Mills at Lead, S. D. R. L. Herrick. Min & Min—Apr., 08. 2 figs. 900 w. 40c. Describes apparatus for automatically feeding the dust to the gold solution.

Slime Treatment.

Treatment of a Concentrate-Slime. A. E. Drucker. Min & Sc Press—Apr. 4, 08. 2 figs. 2400 w. 20c.

IRON AND STEEL.

Blast Furnaces.

A Down-Draft Blast Furnace. R. L. Lloyd. Eng & Min Jl—Apr. 11, 08. 1 fig. 800 w. 20c. Describes a furnace in Chile operated in this manner.

Preparation of Materials for the Blast Furnace. David Baker. Eng & Min Jl—Mar. 21, 08. 2200 w. 20c. Describes the kiln treatment of fine iron ore and residues which reduces the sulphur content and forms nodules of desirable size for smelting.

The Analysis of Blast Furnace Tuyères and Similar Castings. M. Anderson. Ir Age—Apr. 2, 08. 1000 w. 20c.

The Blast-Furnace Diagram. C. Brisker. Stahl u Eisen—Mar. 18, 08. 9 figs. 4500 w. 60c. Gives diagrams whose ordinates represent volume percentages of CO and CO_2, and abscissas the temperatures at various sections of the furnace; of use in the study of the blast-furnace process and in comparing the different types of furnaces.

The New Iron Works of the Staverley Co. Engg—Mar. 27, 08. 27 figs. 4000 w. 40c. Describes in detail the new blast furnace and equipment of the Devonshire works of this coal and iron company at Barrow Hill, Chatfield, England.

Briquetting Iron Ore.

Gröndal Concentrates and Briquettes. Ir Age—Apr. 9, 08. 1800 w. 20c. Sums up the recent development of this process used on the fine iron ores of Norway.

Electric Smelting.

Possibilities in the Electric Smelting of Iron Ores. Alfred Stansfield. Can Min Jl—Apr. 1, 08. 3100 w. 40c. Paper read at the Ottawa meeting of the Canadian Mining Institute.

The Induction Furnace and Its Use in the Steel Industry. Electrochem & Met Indus—Apr., 08. 11 figs. 1100 w. 20c.

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New Method for Manufacturing Low-Carbon Ferro-Alloys. B. Neumann. Stahl u Eisen—Mar. 11, 08. 1 fig. 3000 w. 60c.

Nomenclature of Iron and Steel.

The Uniform Nomenclature of Iron and Steel. Bull Am Inst Min Engrs—Mar., 08. 4500 w. $2. Report of Committee 24, of the International Association for Testing Materials, presented at the Brussels Congress, 1906. Gives the names of the chief classes of iron and steel in English, French, German, Swedish, Danish and Dutch; English definitions of principal classes of iron and steel; glossary of special sizes and shapes of iron and steel; and notes on the boundary between steel and cast iron.

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Some Suggestions for the Improvement of Steel Rails. A. L. Reading. Can Engr—Mar. 20, 08. 1800 w. 20c.

Strength and Endurance of Steel Rails. James E. Howard. Ir Age—Mar. 26, 08. 6 figs. 3500 w. 20c. Paper read at the ninth annual meeting of the American Railway Engineering and Maintenance of Way Association, Mar. 17-19, 08. Discusses the results of the Watertown laboratory's investigation.

Testing of Steel.

The Work of the Testing Department of the Watertown Arsenal in Its Relation to the Metallurgy of Steel. James E. Howard. Bull Am Inst Min Engrs—Mar., 08. 2000 w. $2. Paper read at the New York meeting of the A. I. M. E., Feb., 08.

NICKEL.

Recovery from Oxide and Silicate Ores.

Recovery of Nickel from Oxide and Silicate Ores. William Koehler. Electrochem & Met Indus—Apr., 08. 900 w. 40c.

SILVER.

Cobalt Ores, Concentration of.

Concentrating Cobalt (Ont.) Ores. G. H. Gillespie. Can Min Jl—Apr., 08. 1 fig. 3300 w. 40c.

Cyaniding.

Cyanidation of Silver Ores at Guanajuato, Mexico. Bernard Macdonald. Eng & Min Jl—Apr. 4, 08. 4 figs. 6000 w. 20c.

Cyanidation of Silver Ore in Mexico.—I. W. A. Caldecott. Min & Sc Press—Mar. 28, 08. 2700 w. 20c.

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A Small Lixiviation Plant in Mexico. H. A. Horsfall. Min Wld—Mar. 28, 08. 3 figs. 2900 w. 20c.

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Metallurgy of Zinc.

Recent Advances in the Metallurgy of Zinc. Woolsey McA. Johnson. Jl Fklin Inst—Mar., 08. 5300 w. 40c.

The Metallurgy of Zinc. J. W. Richards. Electrochem & Met Indus—Apr., 08. 2800 w. 40c. Discusses the roasting of sphalerite and gives two problems illustrating the calculations involved.

Roasting.

Williey Roasting Process. J. M. McClave. Min & Min—Apr., 08 1 fig. 900 w. 40c. Describes a new method of roasting sulphide ores to prepare them for magnetic concentration.

MISCELLANEOUS.

Arsenic, Rapid Method for Estimating.

A Rapid Method for the Estimation of Arsenic in Ores. Hartley E. Hooper. Can Min Jl—Mar. 15, 08. 1200 w. 40c. A paper read before the Institute of Mining and Metallurgy.

Assaying.

Losses in Scorification and Cupellation of Lead Buttons. George T. Holloway and Leonard E. Pearse. Min Wld—Mar. 28, 08. 1200 w. 20c. From a paper on the Assay of Telluride Ores read before the British Dist. of Mg. & Met., Dec. 19, 07.

Diaphragms.

Diaphragms. J. R. Crocker. Electrochem & Met Indus—Apr., 08. 9 figs. 2300 w. 40c. Gives a concise and brief description of the many attempts which have been made to meet varied requirements where diaphragms are necessary.

Sintering Process.

The Dwight and Lloyd Sintering Process. Arthur S. Dwight. Eng & Min Jl—Mar. 28, 08. 3 figs. 2600 w. 20c. Describes a new blast-roasting process in which the material is sintered continuously in thin layers, which have a peculiar cellular structure.

MINING ENGINEERING

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Fighting the Fire at the Homestake Mine. H. O. Phythereck. Min & Min—Apr. Bruce C. Yates. Eng & Min Jl—Mar. 28, 08. 4 figs. 5000 w. 20c. Describes methods used: with hose, smothering with steam, and finally by flooding.

Prevention of Accidents In and Around Mines. H. O. Prytherck. Min & Min—Apr., 08. 1600 w. 40c. Precautions suggested from experience and recommended for anthracite mines.

Rescue Appliances in the Mines of France. Jacques Boyer. Eng Mag—Apr. 08. 16 figs. 6500 w. 40c.

Asphalt.

The Tar-Sands of the Athabasca River, Canada. Robert Bell. Bull Am Inst Min Engrs—Mar., 08. 2 figs. 4400 w. $2. Paper read at the Toronto meeting of the A. I. M. E., July, 07.

Canada, Mineral Production of.

Mineral Production of Canada. Eng & Min Jl—Mar. 21, 08. 3600 w. 20c. A summary of the preliminary report of the mineral production of Canada in 1907, as prepared by John McLeish, Statistician, under direction of Dr. Eugene Haanel, director of mines.

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Claims, Government Inspection of.

Government Inspection of Mining Claims. J. B. Tyrrell. Min Wld—Mar. 21, 08. 2 figs. 1400 w. 20c.

Coal.

A Practical Classification for Low-Grade Coals. Marius R. Campbell. Economic Geology—Mar.-Apr., 08. 3 figs. 2700 w. 60c. Published by permission of the Director of the United States Geological Survey.

Coal Formation. Prof. Vivian B. Lewis. Prog Age—Apr. 1, 08. 5000 w. 20c. First of a series of Cantor Lectures upon fuel and its future, delivered Mar. 9, before the Society of Arts, London.

Coal Screening, Washing and Briquette-Making Plant at the Alstadter Collieries, Germany. Ir & Cl Tr Rev—Apr. 3, 08. 20 figs. 3500 w. 40c.

Condition of the Coal Briquetting Industry in the United States. Edward W. Parker. Am Gas Lt Jl—Mar. 23, '08. 6000 w. 20c.

Moisture in Coal. E. E. Somermeier. Min & Min—Apr. 08. 2800 w. 40c. Discusses the importance of proper care of samples for analysis.

Southern Extension of the Kootenai and Montana Coal-Bearing Formations in Northern Montana. Cassius A. Fisher. Economic Geology—Jan.-Feb., 08. 10,000 w. 60c.

The Recovery of Anthracite from Culm Banks. Richard Lee. Eng & Min Jl—Apr. 4, 08. 3 figs. 2200 w. 20c. Describes a plant costing $25,000 to complete, with which it is possible to make a yearly profit of 168% on the investment.

The Sagamore Clearfield District, Pa. Bituminous Coal Mines. Edward K. Judd. Eng & Min Jl—Mar. 21, 08. 4 figs. 1200 w. 20c.

The Southern Pa. Anthracite Coalfield. John H. Jaertter. Eng & Min Jl—Mar. 28, 08. 7 figs. 2300 w. 20c. States that the important future supply of hard coal will be produced by deep mining in the lower basin, and that water hoists will be used to replace pumps.

The Storage of Anthracite Coal. Eng Rec—Mar. 28, 08. 1900 w. 20c.

The Use of Steel Supports in Coal Mines. R. B. Woodworth. Eng & Min Jl—Mar. 21, 08. 3 figs. 1600 w. 20c. Abstract of an address made at Pittsburg, Dec. 21, 07., before the Coal Mining Institute of America.

Concrete in Mining.

The Utilization of Concrete in Mining Work. Ernest McCullough. Min Wld—Apr. 11, 08. 2 figs. 4800 w. 20c. Describes its use for foundation work and other purposes, including the construction of reinforced concrete beams, with formulas for calculating compression and tensile stresses. The design and construction of a reinforced-concrete bin, 20 ft. square, inside, and holding 6 ft. of coal is also indicated.

Copper.

Foothill Copper Belt of the Sierra Nevada. John A. Reid. Min & Sc Pr—Mar. 21, 08. 5 figs. 4000 w. 20c.

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The Copper and Tin Deposits of Katanga, Congo Free State, Africa. John R. Farrell. Eng & Min Jl—Apr. 11, 08. 12 figs. 5500 w. 20c.

The Evergreen Copper Deposits of Colorado. Etienne A. Ritter. Min Wld—Mar. 21, 08. 1800 w. 20c. Abstract of paper read before the Am. Inst. of M. E. Toronto, meeting.

The Utah Copper Mill Near Garfield, Utah. Robert B. Brinsmade. Min Wld—Apr. 4, 08. 6 figs. 2800 w. 20c.

Diamonds.

Notes on Cost of Diamond Drilling in the Boundary District. Fred. Keffer. Can Min Jl—Mar. 15, 08. 2600 w. 40c. From the Journal of the Canadian Mining Institute.

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Drainage in Cripple Creek, Colorado, Gold Camp. T. R. Countryman. Min Sc—Apr. 2, 08. 3000 w. Apr 9. 1 fig. 2200 w. Each 20c. Gives comparison of depths and advantages of several tunnels, and a short account of the selection of the Gatch Park site.

Drilling and Shaft Sinking.

Air Drill Practice in the Joplin District. Otto Ruhl. Min Sc—Apr. 9, 08. 2 figs. 1600 w. 20c.

Deviation of Bore-Holes. Joseph Kitchin. Min & Sc Press—Apr. 4, 08. 2 figs. 3800 w. 20c.

Methods and Cost of Sinking a Shaft on the Rand with Some Good Suggestions on Drilling. Engg-Contr—Mar. 18, 08. 3 figs. 3100 w. 20c.

Gold.

Ore Deposits of the Eastern Gold-Belt of North Carolina. W. O. Crosby. Bull Am Inst Min Engrs—Mar., 08. 3300 w. $2.00. Paper read at the Toronto meeting of the A. I. M. E., July, 07.

The Assay of Telluride Ores. G. B. Halloway and L. E. B. Pearse. Min Wld—Mar. 14, 08. 1900 w. 20c.

The Mt. Lyell Copper Field, Tasmania.—I. Ralph Stokes. Min Wld—Mar. 21, 08. 2 figs. 1900 w. 20c.

The Seven Troughs Mining Districts, Nevada. Wm. M. Hauck. Eng & Min Jl—Mar. 28, 08. 3 figs. 1000 w. 20c.

Graphite.

Modes of Occurrence of Canadian Graphite. H. P. H. Brumell. Can Min Jl—Mar. 15, 08. 2500 w. 40c.

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Industrial Magazine, Park Row Bldg., New York.
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Gypsum.

Gypsum, Where Found, Its Use, and Its Manufacture. C. O. Bartlett. Ir Tr Rev—Mar. 26, 08. 1400 w. 20c. A paper to be presented before the American Mining Congress.

Hoisting and Haulage in Mines.

Accidents in Winding, With Special Reference to Ropes, Safety Cables and Controlling Devices for Colliery Winding Engines. G. H. Winsteiner. Ir & Cl Tr Jl—Mar. 13, 08. 7000 w. 40c. Abstract of paper read March 10, before the Manchester Geological and Mining Society.

Advantages of Electrical Haulage. Fred. Norman. Min & Min (Denver)—Mar. 27, 08. 3200 w. 20c. Compares the different kinds of haulage and states the conditions favorable to each.

The Design of Cages for Modern Collieries.—I. J. S. Barnes. Iron & Cl Tr Jl—Apr. 3, 08. 8 figs. 2500 w. 40c. Discusses the various factors entering into the design of pit cages for heavy loads operating at high velocities.

Iron.

Brown-Ore Mining in the Russellville District, Alabama. F. Wm. Hausmann. Stev Inst Ind—Jan., 08. 3 figs. 1800 w. 60c.

Chrome Iron Mining in Canada. H. F. Strangway. Min & Min (Denver)—Apr. 3, 08. 3 figs. 4800 w. 20c. A paper read before the Mining Section of the Canadian Society of Civil Engineers.

Iron Mining in Cuba. Ir Age—Apr. 9, 08. 13 figs. 9500 w. 20c. Describes the old and new properties of the Spanish American Iron Company.

The Iron Ores of Ontario. A. B. Willmott. Can Min Jl—Mar. 15, 08. 1 fig. 1600 w. 40c.

Jigs and Screens.

Experimental Studies on the Work of Water Jigs. Eng & Min Jl—Mar. 28, 08. 2000 w. 20c. Abstract of paper by Gust. Bring, in "Jernkontorets Annaler," 1906.

Nomenclature in Screen Sizes. Edwin A. Sperry. Min Sc—Apr. 2, 08. 1 fig. 1000 w. 20c.

Lead.

Lead: Its History and Economic Development.—I. Evans W. Burkett. Min Wld—Mar. 14, 08. 1100 w. Mar 21. 2200 w. Each, 20c.

Mexico.

Character and Habits of the Mexican Miner. Allen H. Rogers. Eng & Min Jl—Apr. 4, 08. 3300 w. 20c.

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Empire Building in Western Mexico. Percy E. Barbour. Eng & Min Jl—Apr. 4, 08. 3 figs. 3200 w. 20c. Gives details of great areas of mineral lands from which millions have been extracted by ancient miners, which will be opened by new railroads.

Mining Costs and Accounts.

Mine Accounts for the Superintendent. Algernon Del Mar. Min & Sc Press—Apr. 4, 08. 420 w. (including forms.) 20c.

Transportation, Costs and Labor in Central Peru. J. C. Pickering. Eng & Min Jl—Mar. 21, 08. 3 figs. 2300 w. 20c.

Variations in Mining Costs. John B. Hastings. Min & Sc Press—Mar. 28, 08. 4300 w. 20c.

Ore Deposition.

A Theory of Ore Deposition. H. V. Winchell. Min & Sc Pr—Mar. 21, 08. 2500 w. 20c.

A Theory of the Origin of Ore Deposits.—II. and III. J. E. Spurr. Min Wld—Mar. 28, 08. 1200 w. Apr. 4. 1100 w. Each, 20c.

Ore Dressing.

Crushing Ore. M. P. Boss. Min & Sc Press—Mar. 14, 08. 10 figs. 5500 w. 20c. Describes the various types of crushing devices, wear, etc.

The Present Status of the Art of Ore Dressing. W. G. Swart. Min Science—Mar. 28, 08. 2800 w. Apr. 2. 1900 w. Each, 20c. Discusses the general problems of concentration and separation in the hydraulic, pneumatic, magnetic and static fields. From the Western Chemist and Metallurgist, March, 08.

Phosphorus.

Distribution of Phosphorus in the Pittsburg Coal Seam. J. R. Campbell. Min & Min—Apr., 08. 1 fig. 2100 w. 40c. Comparison of analyses of top, bottom, and other parts of the seam in different mines.

Russia, Mining Conditions In.

The Bogoslovsk Siberia Mining Estate. William H. Shockley. Bull Am Inst Min Engrs—Mar., 08. 8 figs. 11,000 w. $2.00. Paper read at the New York meeting of the A. I. M. E., Feb., 08. Gives an account of a large Russian mining estate where the conditions differ widely from those in the mining regions of the United States.

Silver.

Promontorio Silver Mine, Durango, Mexico. Francis C. Lincoln. Eng & Min Jl—Apr. 11, 08. 3 figs. 3600 w. 20c.

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Turbine Fans in Mine Ventilation. Daniel T. Pierce. Eng & Min Jl—Apr. 11, 08. 2 figs. 1100 w. 20c.

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Notes on Zinc. A. Humboldt Sexton. Mech. Engr—Mar. 27, 08. 8 figs. 2200 w. 40c. II.—Dressing, calcining and roasting ores.

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Present-Day Road Requirements in Town and Country. A. Brown. Eng Rec—Mar. 21, 08. 5500 w. 20c. A paper read before the Royal Sanitary Institute by the City Engineer of Nottingham, Eng.

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Some Construction Methods on Metropolitan Work. Howard S. Knowlton. Eng Rec—Apr. 4, 08. 7 figs. 1800 w. 40c. Describes some of the methods adopted in the construction of the extensive sewerage system in the Boston Metropolitan District.

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Some Jigs and Devices Used in Canadian Railway Shops. John T. Summer. Can Machy—Apr., 08. 19 figs. 2300 w. 20c. Describes jigs for valve-stem packing, patch bolts and methods of removing piston rods and studs, cutting flue sheets, turning crank pins, making air-pump rings, machining axle boxes, boring driving-box brasses, etc.

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A Method of Uniform Signaling. Ry & Eng Rev—Mar. 21, 08. 2 figs. 3000 w. 20c. From a report of the committee on signal and interlocking to the convention of the American Railway Engineering and Maintenance of Way Association, Chicago, Mar. 17, 08.

Steel Cars.

Steel Car Construction and Maintenance. G. E. Carson. Ir Tr Rev—Mar. 19, 08. 2700 w. 20c. Paper presented before the Railway Club of Pittsburg at its regular monthly meeting, Feb. 28, 08.

Steel Passenger Equipment. Charles E. Barba and Marvin Singer. Am Engr & R R Jl—Apr., 08. 5000 w. 40c. III.—The underframe: the center sills as a column; transverse supports; floor girders.

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THE WORK OF THE FOREST SERVICE.

By GIFFORD PINCHOT *

SLIGHTLY CONDENSED FROM "AMERICAN INDUSTRIES"

The work of the Forest Service lies along two distinct lines. One line is administrative, the other educational. The purpose of the first is to manage the 165,000,000 acres of land included in National Forests so as to make them as useful as possible to the public. The purpose of the second is to bring about the best possible use of forest lands and forest products on the part of the people generally.

The forests of the United States are indispensable to our national welfare. They cover something like one-third of our land surface. This might seem to mean that with such an enormous supply we are in no danger of suffering for wood. But the trouble is that vastly the greater part of this forest area has had its stand of merchantable timber partly or entirely cut off under methods which have severely reduced the forest's power to renew itself. In point of fact a good deal of what is classed as forest is mere brushland, so devoid of value that oftentimes it is not worth paying taxes on. Rich as we are, we cannot afford to turn one-third of our national estate into an artificial desert.

But the reasons why the treatment we give our forest lands is one of our great public questions go even deeper than this. The yearly addition to our national wealth made by the farms of the country is, of course, many times greater than that made by its forests, which as a rule occupy and should occupy the land of lowest productive value—land that is too steep, high, rocky, sterile, or wet for the plow; but the farmer would find it difficult to get along without the wood, and in much of the West impossible to get along without the water which the forests furnish. Again, more of our mineral wealth is converted into money each year than of our forest wealth; but most of our mines simply could not be worked without supplies of timber in great quantities. Our streams and rivers are a national asset of a value which we are only beginning to realize; yet the result of forest destruction will be to convert them from a blessing into a curse.

Wood is even more than iron an article of universal daily use, a basic material in our industrial life. Let any man imagine to himself, if he can, from the time that he rises in the morning until he lies down again at night, how his own convenience and comfort and employment would be affected—will be affected—by a serious shortage in the supply of wood, and what substitutes could serve the same needs. He will then realize the incredible blindness of those who assure us that there is no occasion for alarm—that some way will be found by an ingenious people to get along as well when we have reached the end of our present wood supply as we have got along in the past.

*Forester in Chief of the U. S. Forest Service.

It is a sober fact that not only the United States but the whole civilized world faces an approaching timber-famine. For centuries Europe has been consuming more wood than her forests have produced. With an ever increasing density of population the excess of consumption over production has tended also to increase. This tendency has been, to some degree, counteracted by the results of scientific forestry, which has, for example, multiplied by five the average production of wood per acre on the government-owned German forests.

For the United States no great relief can be counted on from outside sources. Contrary to wide-spread impression, Canada will be able to afford us at most only very temporary relief. Her area of commercial forest is far smaller than it was commonly supposed to be; the demands of her own rapidly developing country will have to be met and there is certain to be increasing demand for Canadian timber in Great Britain, which has only four per cent. of its area forested. The tropical forests to the south of us, like those of the Philippine Islands, produce many woods which will be valuable to us for special purposes, but not such woods as our general lumber market calls for. The Siberian forests, besides being far from us, will be subject to demands which will take precedence of ours. They are also like the Canadian forests in that, from their northern latitude, they make wood very slowly. Once cut over, they cannot have ready a second crop for a very long time. In the long run, we in the United States will have to grow most of our own wood, or do without.

One of the purposes of forestry, though by no means the sole and sometimes not the first purpose, is to make woodland produce as abundant, frequent and valuable timber crops as possible. In common with farming, it seeks to make the most of the resources presented by the soil. Like farming, it improves on nature, though not to the same extent. A cultivated forest produces wood considerably faster than a wild one. It is not simply that the forester removes the timber as it matures and converts it to use instead of letting it go to decay; he plans his operations so as to produce the kinds of trees that he wants, under conditions which will yield the highest rate of production and the best quality of material for the specific purpose which he has in view. The further he can carry the cultivation of the forest, the greater will be the returns.

The first duty of the Forest Service is to protect the National Forests. These forests are mainly virgin in the sense that but little of their area has been cut over. They are not, however, virgin in the sense of being fully stocked with timber. A fully established forest which has never been interfered with does not gain. It makes no more wood by growth than it loses by decay. Most of the forested area in the West, however, has been severely interfered with for many years, chiefly by fire. The most serious part of the damage caused by the ordinary forest fire is that done to the young growth, from the tiny seedlings in their first year up. To this damage by fire must be added the heavy damage caused in the past by the over-grazing of stock, and especially of sheep.

With the checking of these and other abuses through administration by the Government, the quantity of timber on the National Forests is on the increase again. Even were no timber cut, the present supposed stand of 350,000,000,000 board feet of timber on the National Forests would be adding very materially to its quantity each year that fires are kept out. It may be said in passing that the fire loss on these forests is now reduced almost to a negligble figure. If the entire cost of the forest administration for the last fiscal year were charged to the account of fire protection, it would be equivalent to an insurance charge of something like $2 per $1,000.

To bring the forests to their full productiveness, however, they must be cut over. The ax is the forester's hoe as well as his scythe. Reaping and sowing are usually for him one and the same operation, and cultivation is accomplished by getting rid of what he does not want. There were cut from the National Forests during the last fiscal year the equivalent of a little over 280,000,000 board feet of timber. This involved cutting operations on slightly less than 360,000 acres of land, or about one four-hundredth of the total area of the Government's forests. In other words, hardly a beginning has been made in bringing the forests to their highest productiveness through use, and their reserve of mature timber has scarcely been touched by the operations under way.

Timber cutting on the National Forests has hitherto been done almost entirely by what foresters call the "selection method." This takes out only a part of the trees and leaves the rest to grow more rapidly as a result of the opening up of the forest, while permitting also the seeding up of the ground with new

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AN EXAMPLE OF GOOD FORESTRY: SCENE IN NATIONAL FOREST IN THE WHITE MOUNTAINS

Photo. U. S. Forest Service, Washington, D. C. "Forestry Literature."

growth. Still, that he has to be assisted by a Forest Service is a confession of failure on the part of Nature, and report of the Forest Service of the United States for the year ending June 30, 1910, by Mr. Graves, of Yale, Chief Forester of the United States Department of Agriculture, and Mr. Pinchot, Washington, the first Chief Forester, is a record of the efforts of the United Governor of Forestry, is a record of the efforts of the United States Government to help Nature in the work of reforestation. The report is a very interesting one, and it may be useful to us to review briefly the work it describes.

The Forest Service is a branch of the Department of Agriculture, and it is charged with the duty of protecting the forests of the United States. Why the United States and not the country, the State, or the individual proprietor, is charged with this protective duty is not explained in the report. Reforestation is charged to the Forest Service. Reforesting over forty square miles, however, is not a task that can be undertaken by the State of Ireland. The conservation of the forests of the United States is a matter of national importance. The forests have much more room than it had a hundred years ago, and the work of the Forest Service is to see that the forests that are not forested shall be forested. The Forest Service has also the beneficial interest who in case not to settle in the forests, and to see that the forests are not cut for the benefit of a few. The Forest Service has also the duty of seeing that the forests are not cut down to such an extent that the water supply is affected. The whole report is a very interesting one, and it may be useful to us to review briefly the work it describes.

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POSSIBILITIES IN THE ELECTRIC SMELTING OF IRON ORES*

By ALFRED STANSFIELD

In view of the many recent attempts that have been made to employ electrical energy instead of fuel for the smelting of iron ores, it appears worth while to indicate what can probably be accomplished in this direction, the manner in which the successful results can be obtained, and the advantages and drawbacks of the electrical process.

Electrical energy has recently been employed to replace, in metallurgical operations, the heat which is ordinarily obtained by burning fuel. It is somewhat expensive, and was naturally employed at first for the production of the more valuable products, such as crucible steel, which is used for tools, where the cost is of less importance. The electrical production of cast steel for tools and similar purposes may be accomplished in two ways—(1) by melting down pure varieties of iron and steel with suitable additions of carbon and other ingredients, just as in the crucible process, but using electrical energy for heating instead of coke or gas; (2) by melting a mixture of pig iron and scrap steel as in the open-hearth process, and removing the impurities, such as sulphur and phosphorus so thoroughly by washing with basic slags that a pure iron is at last obtained. This can be recarburized and poured into moulds. Both these methods are employed commercially for the production of good qualities of tool steel. The larger sizes of electrical furnaces already constructed hold 5 to 10 tons, while the crucible only holds about 80 lbs., and the high efficiency of the electrical method of heating more than compensates for the greater cost of electrical energy as compared with heat derived from fuel. The steel is found to be even better than crucible steel, and can be produced at less cost. It is, therefore, only a question of time until the crucible process shall be replaced by the electrical process in all localities where electrical energy can be produced at a moderate figure.

Two forms of electrical furnace have been used for making cast steel:—(1) the Héroult steel furnace, which resembles an open-hearth furnace, through the roof of which hang two large carbon electrodes. Electrical connections are made to these carbon electrodes and electric arcs are maintained between the lower end of each electrode and the molten slag in the furnace, thus producing the necessary heat. This form of furnace has been found to be suitable for the process in which pig iron and scrap steel are melted together and refined.

A different form of furnace has been devised in which no electrodes are required. This furnace consists of an annular shaped trough containing the steel. The ring of steel acts as the secondary of an electrical transformer. An alternating current is supplied to a primary winding, and the primary winding and the ring of steel encircle an iron core, as in the ordinary transformer. The alternating current in the primary circuit induces a large alternating current in the secondary circuit, the ring of steel, and enough heat is produced to melt the steel. This type of furnace has been constructed lately holding as much as 8 tons of steel and consuming 1,000 E. HP. It is apparently suited for the process of melting down pure iron or steel as in the crucible process.

The energy needed in these furnaces is about 800 or 900 KW.-hrs. per ton of steel, using cold stock, or 600 or 700 KW.-hrs. when the pig iron, usually a part of the charge, is supplied molten. This amount of electrical energy costs more than the coal used in producing the same amount of steel in the open-hearth furnace, but the steel is more valuable than the open-hearth steel.

In reducing iron ore to a metal in the small furnace or hearth used by the ancient metallurgists, iron can be obtained in a relatively pure state, such as wrought iron, but in the blast furnace the coke needed for the production of heat carburizes the iron, producing pig iron. In the electric furnace, however, fuel is not used for producing heat, since this is obtained electrically. Some carbonaceous material must be added to the charge to eliminate the oxygen of the ore yielding metallic iron,

*Condensed from a paper read before the Ottawa meeting of the Canadian Mining Institute.

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but the amount of this material can be regulated to yield pure iron, steel or pig iron at will.

Although this has been realized by the pioneers in the electric smelting of iron ores, certain difficulties in the operation have led them to smelt the ore for the production of pig iron instead of for the production of steel, although the difference in price of these materials would be sufficient to pay for all the electrical energy needed for the direct production of steel from iron ore, and it is surprising that this more attractive proposition has not gained more attention from metallurgists.

A number of experiments have been made on the direct reduction of steel from iron ore in the electric furnace, but the most satisfactory work that has been accomplished relates to the production of pig iron from the ore, carried out by Héroult, Keller and others. The furnaces they have adopted are similar to the one employed by Héroult recently in the experiments at Sault Ste. Marie. This consisted of a vertical shaft similar to a small blast furnace, in which hung a central carbon and served as one electrode, the electric current passing between the hanging electrode and the molten metal in the crucible of the furnace. The ore, with fluxes and carbon sufficient for its chemical requirements, was fed in around the vertical electrode, and became heated and melted by the heat produced by the passage of the current. The current in this furnace produces enough heat to carry out the chemical reactions involved in the reduction of the ore to metal, and the fusion of the resulting pig iron and slag. The carbon is required for the reduction of iron oxide to metal and for the carburization of the metal to form pig iron.

The Keller furnace is practically the same as the Héroult furnace, except that it consists of two shafts instead of one and that these two shafts are worked in conjunction with one another, the current entering through the vertical electrode in one shaft and leaving by the vertical electrode in the other shaft. A connecting trough or passage enables the electric current to flow from one part of the furnace to the other, and serves to collect the resulting pig iron and slag from both of the shafts. This has the advantage of using a higher voltage than the single shaft furnace of Héroult. (For further description of the various types of electric furnaces see Eng. Dig., Vol. III., No. 3, p. 277.) The results of operating furnaces of this class show a consumption of electrical energy of about 0.3 HP.-yr., and about 800 or 900 lbs. of coke or good charcoal per long ton of pig iron. Supposing that the general costs of operating this furnace and the blast furnace were equal, these figures would indicate that the electrical furnace would need to obtain energy at a cost per HP.-yr. of less than that of two tons of coke in order to compete with the blast furnace. Thus, if coke costs $3 a ton and electrical energy $5 per HP.-yr., the cost would be about the same by the two processes, and with power at $12 per HP.-yr., the electric furnace could not compete with the blast furnace unless the price of coke were as high as $7 per ton. In considering these figures it should be remembered that the heating power of one E. HP.-yr. is about the same as that of three-quarters of a ton of good coal or coke, assuming that the latter is completely burned. Looked at from this point of view, it will be obvious that even these small and admittedly imperfect electric furnaces are more economical, that is to say, they use the heat better than the large blast furnaces.

The electrical furnace possesses certain advantages over the blast furnace, which in some cases may override the high cost of electrical power. One is its ability to use without much trouble ores of a sandy or powdery character. This ability depends upon the absence of a blast in the electrical furnace. In the blast furnace powdery ores are liable to be blown out of the furnace by the blast, or to obstruct the passage of the blast through the furnace. In the electric furnace there is no blast introduced, and these difficulties are less serious. Another advantage of the electric furnace is in regard to the smelting of titaniferous and other difficultly fusible ores. In the blast furnace these ores may give trouble on account of the slag becoming pasty, but in the electric furnace it is possible to obtain a higher temperature and thus overcome difficulty of this kind. The high temperature obtained in the electric furnace is advantageous in regard to the treatment of sulphurous ores. In the iron blast furnace, the sulphur in the coke or the ore is prevented from entering the pig iron by the presence of lime and by maintaining strongly reducing conditions in the furnace; the lime then forms calcium sulphide, which passes into the slag. In the electric furnace the higher temperatures enable a larger proportion of lime to be used, and even more strongly reducing conditions to be obtained than in the blast furnace and large amounts of sulphur can, therefore, be eliminated.

Another point is that the electric furnace does not require a very high quality of coke or fuel. In the blast furnace a soft or powdery coke becomes crushed, obstructs the action of the furnace, and is less efficient than a harder variety; but in the electric furnace, where the coke is needed merely as a chemical reagent, any convenient form of carbon can be employed—coke, charcoal or small anthracite—and probably in improved furnaces such fuel as peat, sawdust or soft coal could be utilized for reduction.

From a commercial point of view the electric furnace producing pig iron has many difficulties to overcome before it can compete successfully with the blast furnace. One difficulty is the small scale on which the electric furnace has so far been constructed. In the Héroult furnace the height of the shaft is limited by the length of the electrode introduced into it. More recent furnaces have been designed by Dr. Haanel and by Mr. Turnbull, in which this difficulty has been overcome by a system of inclined or lateral shafts down which the ore passes, so that the electrode does not hang down the whole height of the ore column. Another weak point in the construction of the electric furnace is that no provision is made for utilizing the carbonaceous gases which escape at the top of the furnace. In the Turnbull furnace, however, it is proposed to utilize the gas by burning it in a rotating tube furnace down which the ore passes before it enters the electric furnace and is mixed with the charcoal. In this way the heat available will be utilized, and an economy in the working may be expected.

In view of the importance of reducing the consumption of fuel and electrical energy, the writer has calculated what could be expected if the gases arising from the reaction between the charcoal and the ore were used partly for the reduction of the ore and partly for preheating the ore. Such a result could be attained in a furnace consisting of three parts. In the upper part the waste gases are burned by air introduced there and communicate their heat to the incoming ore to which the fluxes have been added. In the middle portion of the furnace the gases arising from the lowest portion react on the heated ferric oxide, if that were the variety of ore to be treated, and reduce it to ferrous oxide. The charcoal is introduced in the lowest section of the furnace and completes the reduction of the ore. Electrical energy is introduced into this section of the furnace and serves to melt the resulting pig iron and slag, and to supply the heat necessary for the preceding chemical reactions. In a furnace of this kind it can be calculated that taking into account the loss of heat and allowing for the irregularity in the electrical power, one ton of pig iron can be obtained from an average ore by the use of 0.25 HP.-yr. and 600 to 800 lbs. of coke or charcoal.

Considering these figures, it will be seen that the use of 0.25 E. HP.-yr. will save about 2/3 of a ton of coke, or that 1 E. HP.-yr. should not cost more than 2 2/3 tons of coke, if the electrical furnace is to compete with the blast furnace. Thus, an electrical HP.-yr., at $12, would correspond to coke at $4.50 a ton. The considerations in regard to the use of cheaper fuel and cheaper ore in the electric furnace would also apply in this case, and with improved design and construction the size of the electric furnace may be increased to admit of a large and economical output of pig iron.

The direct reduction of steel from the ore has been carried out by Stassano and others, but no economical scheme for this purpose has been put into operation on a large scale. The Stassano furnace consists of a chamber, about one and one-quarter cubic yards, lined with magnesite bricks. The ore, mixed with the necessary fluxes and charcoal for its reduction and made up into briquettes, is placed in this chamber, and heated by an electric arc, maintained above the ore. In this furnace it is possible to reduce the ore to metal and to remove any impurities, such as sulphur and phosphorus, although Stassano did not demonstrate this as the ores he employed were very pure. The method of heating the ore is, however, uneconomical. Steel has also been obtained directly from the ore by the Héroult electric furnace, but the process was uneconomical and pig and scrap were therefore used.

In the direct reduction of iron ore to steel the following difficulties should be borne in mind:—

1. The difficulty of eliminating sulphur, when this is present in the ore, the blast furnace producing pig iron being far more efficient in this particular than a steel furnace, such as the open hearth. It may possibly be necessary on this account, only to use ores relatively free from sulphur in the direct production of steel.

2. Another difficulty lies in the different conditions required for the reduction of the ore and the final refining treatment to which the resulting steel must be subjected. Thus the operation of making steel must always be

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intermittent in character, while the reduction of ore in the blast furnace is a continuous operation.

Until these and other difficulties have been overcome, it is not likely that we shall have any successful production of steel directly from iron ore on a commercial scale. At present the most satisfactory method appears to be that of reducing the ore to pig iron in one furnace, and turning this into steel in a separate furnace as in ordinary metallurgical practice.

THE PROBLEM OF ROAD CONSTRUCTION*

A CONSIDERATION OF MODERN AND FUTURE REQUIREMENTS

By DR. H. S. HELE-SHAW, F. R. S., and DOUGLAS MACKENZIE

Quite apart from the mechanical features of road locomotion, involving a necessity of reform in road construction, there is the underlying cause of the increase in the use of roads to-day, the cause in question being the growth of railway traffic to-day.

While the railways are truly the arteries and veins of the nation, and have as such received great attention, very much less consideration has been given to the ordinary roads, which might be considered as the capillaries or feeders, and which are just as vital to the satisfactory working of the system of internal transport as a whole.

The object of the present paper is to consider the problem of road construction, and particularly as to how far the various improvements in the methods of road-making which have been devised and put into operation since the passing of the Light Locomotives Act of 1896 satisfy modern requirements. Also what progress the various new systems of road construction have made towards standardization of modern road-making comparable with that arrived at by the pioneers, Telford, Macadam, and others in their day, for the traffic conditions of their day.

As long as the speed of vehicles was slow, the axle-load moderate, and the tractive effort was not derived from the wheel itself, the surface of a road, even when carrying a considerable amount of traffic, could be kept in fairly good condition by means of a moderate annual expenditure, even when the surface was not very hard, nor the substance of it impervious to moisture.

Under the changed conditions of today, however, the increased expenditure has been so great as justly to alarm the authorities throughout the country responsible for the use of the roads.

Mr. Howard Humphreys, in a paper read recently before the Society of Road Traction Engineers, gave some valuable data on the subject. Some of these facts are worth summarizing. Thus the increase of cost in main roads in thirteen years, from 1892 to 1905, had increased 66.66%. The urban and rural roads between the twelve months ending March 31, 1896, showed the cost of 25,650 miles of main road to be $332 per mile; last year the cost of 27,380 miles of main road was $440 per mile, being an increase of 30.51%. These data all tell the same tale, and that tale is one which can only be heard with the gravest concern, since from it two things are quite evident.

(1) That the rate-paying possibilities in country districts will not be equal to a much further rise in expenditure, even if they can continue to meet the charge what it has risen to at present.

(2) That so far from having reached a state of finality in regard to motor traffic, the increase in expenditure is merely due (or to a large extent due) to what might be called light motor traffic. Heavy motor traffic is yet in a comparatively undeveloped state, with possible increase before it far exceeding that of the future of light traffic.

It is not to be wondered at that public attention is being attracted to a matter which touches everyone so vitally, though it is probable that the dust nuisance—as it is very properly called—has really had more to do with the public interest in the road question than the matter of the increased cost of their upkeep, though, as will be shown, the efficient road must really be, as a natural concomitant, a dustless one.

*From a paper recently read before the Royal Society of Arts.

Proposals have recently been made for the nationalization of the roads, and for the taxation of motor vehicles for road improvement and maintenance. With these questions the present paper does not deal, but rather with the equally important one as to what is the best way of dealing with road construction from the engineering point of view, so as to secure the most efficient road at the lowest cost.

There is only one really sound way of approaching the problem of construction, and that is to regard the road as one element of a mechanical contrivance, of which the wheel is the other element. This aspect of the matter seems too often to be entirely overlooked. Inventors of a wheel and the makers of a road, respectively, too often treat their part of the problem without reference to the other part, whereas these parts are only two halves of a whole.

More than thirty years ago there was translated from the German, by Prof. (now Sir Alexander) Kennedy, the "Kinematics of Machinery," of Prof. Reuleaux, and in that work for the first time the true conception of a machine was set forth. We now realize that the action of a rope on a pulley, water in a hydraulic system, or a wheel on a road, might be considered as much cases of machinal action as that of the two-tooth wheels working in contact with each other. It was truly said in the above work: "A machine may be perfect, or may contain more or fewer imperfections; it aproaches perfection just in proportion as it corresponds to what we have recognized as its special object—the special end for which it has been constructed."

Now the special end for which two elements in the case of a pair (a higher pair as it is called in the case of rolling contact)—viz., the wheel and the road are designed—is that they may run smoothly and in contact with each other, resisting considerable mutual pressures without permanent deformation and without undue wear or loss of energy. The ideal condition of things is obviously that in which a perfectly hard and perfectly circular wheel runs on a perfectly hard and level road. It might be said, therefore, that a steel wheel and a steel road would be suitable as in the case of railway practice. As a matter of fact, quite apart from the practical question of the cost of such a road, there are questions of adhesion, in the matter of gradients as well as steering, that make a metal road quite out of the question. Assuming, then, that a really hard road cannot be obtained, it may be at once said that if a moderately hard road could be kept level and entirely free from all unevenness of surface there could be nothing better than a truly circular metal wheel, and such a wheel being cheap and durable would doubtless be universally employed.

But a thing so desirable as a truly level surface is exactly what it is impossible to maintain, and it is in order to mitigate the shocks caused by the tendency to deflect a vehicle from its movement in the straight course that yielding material such as solid rubber or pneumatic tires are employed on the periphery of a wheel. Now we cannot employ this soft material without paying the penalty, not merely of wearing the wheel, but of wearing the road itself, and as a matter of fact insomuch as the contact between the wheel and the road departs from a point in the side elevation, or a line looked at in plan, by so much is wear between the surfaces in contact introduced. In the next place let us consider what goes on beneath the surface. If the road is not hard, then a certain amount of deformation must take place.

The injury done by this deformation will depend on two things:

(1) The depth to which it will extend (i. e., magnitude of deformation).

(2) The extent of permanent disintegration of the internal substance of the road.

It is obvious from the foregoing remarks that, both as far as the surface is concerned and also the body of the road, what is required is a tough elastic material, or if on the score of expense it is impossible to have such a material for the whole of the road, then the material of which the road is actually composed should be cemented or bound together by such a material.

In any case, as the road is exposed to the action of the weather, one of the very first conditions of its efficiency is that it must be waterproof, and that the surface must be sufficiently hard to prevent as much as possible the formation of liquid material—let us call it mud—in wet weather, and loose, finely-divided particles—let us say dust—in dry weather.

Quite apart from the question of irregularities on the surface, which will not be considered, the difference between the perfect rolling of a hard wheel on a smooth surface, in the case where either the wheel or the road, or both, are soft, demands attention in the study of road construction.

Restrictions have very properly been devised and are enforced by law with a view of protecting the roads from undue destruction by wheels; but it is clear that just as there are demands made for road improvement on the one hand, so will demands be made and vigorously voiced for further restrictions in the matter of wheels on the other. The use of studded tires is a case in point, and the authors think that, concerning its use, road surveyors have a just grievance at the present time. The new studded tire with projecting steel studs and rotated by an engine of 40 to 60 HP. is capable, in passing along the road, especially in climbing hills at a high rate of speed, of doing a considerable amount of damage to the surface of a road, and when scores, if not hundreds, of such tires pass along one piece of road in a day, it is obvious that there is no road surface, unless made of steel itself, that would not be cut to pieces in a short time by such means.

With regard to the types of heavy commercial vehicles, it is certain that unless the diameter of their wheels is increased, they will form, as this class of traffic increases in future, a very serious problem to the road constructor. It is astonishing how much the injury to a road surface is reduced by the comparatively small increase in the size of wheels of steam tractors, which only average about 4 ft. 6 ins. in diameter, as against 3 ft. 6 ins. of a heavy motor vehicle. Of course, even better comparative results are obtained with the much larger wheels of the heavy traction engine, and the authors do not think it is going too far to say that if the wheels of such traction engines were not of the size they are, the passage of one such traction engine on a road, in certain states of the weather, drawing, of course, its full load, would be sufficient to do incalculable damage; that is, assuming it were able to pull its load at all. The authors do not wish to enter farther into the question of the wheel. They have drawn attention to some of the chief points which are of pressing importance in the matter of road construction, and wish, in conclusion, to remark that, while they have shown that there must be sympathetic cooperation between the designer of the wheels of a motor vehicle and the surveyor who is responsible for the maintenance of the road, there is a third party who has a serious responsibility in the matter —namely, the user of the road.

However good the road, and however well designed are the wheels, a great responsibility must rest with the driver of a motor vehicle. By the incessant use of the crown of the road, leading to tracking, by the injudicious use of brakes, by the rushing of corners at unreasonable speeds, and in many other ways, the driver of a motor vehicle can do more damage in a week to the roads, as well as to the vehicle he is responsible for, than would otherwise be the result of twelve months' fair usage. The authors trust they have shown that if the drivers and manufacturers do their part the science of road construction has now advanced sufficiently for the road surveyor to be able to do his part without putting an undue and even prohibitive burden upon the community.

NOTES ON MOTOR-CAR DESIGN*

By F. W. LANCHESTER

The function of a suspension is in its essence to permit of the road-wheels following the road surface without the rising and falling and oscillating motions being conveyed to the body. In considering the behavior of a suspension it is sometimes necessary to regard the road-wheels and underframes as fixed, and the body as oscillating; but it is, generally speaking, more correct to look upon the body of the car as stationary and the motion as confined to the underframes, as would be the case were a perfect suspension possible.

In the forms of suspension in common employment the elastic connection between the car body and the underframe consists of a combination of springs of the laminated type, giving a considerable range of freedom in a vertical direction, but a comparatively small range of freedom laterally. The lateral freedom is, in fact, so small that the customary type of spring may be said to provide a more or less definite side location.

*From a paper read at the Incorporated Institution of Automobile Engineers, March 11, 1908.

In practice, owing in part to the slight degree of lateral flexibility of the springs (which may amount to some ½ inch or so), and in part to the freedom permitted by the "shackling" of the springs in some cases, the side location is not so rigid as to enforce the whole of the lateral motion on the body; but in any case the quantity h—that is to say, the height of the side location above the ground level — should be kept as small as possible, for, other things being equal, the amplitude of the side wobble will be proportional to h.

Suspension Period.—The criterion of the "softness" or "hardness" of a suspension is the suspension period; the quicker the period the harder the suspension, and vice versa.

If there were no practical limitations to the period attainable, the slower the period the greater the comfort; it is therefore the object of the designer to obtain as slow a period as is compatible with the other conditions.

It can be shown from theoretical considerations that the period of any given suspension is the same as that of a pendulum whose length is equal to the linear deflection of the springs under load; thus, if we suppose that the weight of a car body be entirely removed from the springs by raising it on a crane, so that the weight is just, and only just, relieved, then if l be the height through which the body has been raised, the time period will be that of a pendulum of length = l. The equation from which the period of a single or half oscillation can be calculated is therefore the well-known expression, $t = \pi\sqrt{(l/g)}$, where t is in seconds and l in feet. As a matter of convenience, I have given in Table I., below, the period in complete double swings per minute corresponding to values of l expressed in inches:

Table I.—Number of Oscillations per Minute for Initial Spring Deflection = l.

(Inches.)	Complete Oscillations per minute.
1	188
2	133
3	108
4	94
5	83
6	77

Now it is evident that if an attempt is made to obtain the maximum degree of comfort possible, a limit is very soon reached, for a suspension range exceeding a foot is scarcely permissible, and since the range above and below the normal position should be about equal, this means that the equivalent pendulum length is 6 ins., and the number of complete oscillations per minute = 77. In general this is beyond that which is attainable, though I have sometimes nearly reached this figure; 5 ins. is the most it is usually possible to specify, with a corresponding period of 81. I have found in practice that a period slower than 90 per minute gives an ample degree of comfort, whereas a period quicker than 100, although frequently employed, should be avoided when circumstances permit.

The whole question of the rolling oscillation, and of the couple, or torque, by which it is set up, is a subject of greater complication than at first sight appears, and only the most brief outline can be given in the present paper.

The moment of inertia about the axis of oscillation may be looked upon as the sum of two parts: the moment of inertia of the chassis and body about its own center of gravity, and the moment of inertia of the body as a whole, supposed concentrated at its center of gravity, about the axis of oscillation. Now the first of these is settled once and for all by the body and chassis design, and cannot be altered; the second, however, depends upon the distance of the point of side location from the center of gravity of the suspended mass; this is a quantity that the designer can vary. Thus by raising or lowering the body and chassis as a whole, the second part of the moment of inertia can be made greater or less, or by altering the height of the point of side location above the ground-level similarly an alteration may be made. If, as is frequently the case in a limousine type, the period tends to be too slow, we thus find the designer in a dilemma: he cannot lower the body and chassis as a whole past a certain limit, owing to the underneath clearance necessary; he cannot raise the point of side location without detriment to the perfection of his suspension, both as touching the comfort of the passengers and the wear on the tires; his only recourse is to either stiffen the springs, which quickens the bouncing period and decreases the comfort, or he must widen the lateral spring base—a procedure that cannot be carried beyond a very moderate degree unless the wheel-gage is to be involved. For the above reasons the design of a large, heavy car with much top hamper is frequently a matter of compromise, and the success or otherwise of any given machine will largely depend upon the intelligence of the driver. If the comfort of the suspension alone is considered in design, a car of this

type must be slowed very considerably when rounding corners.

There is one important lesson to be learned, however—that is, the value in any case of a low center of gravity. If the center of gravity is kept as low as possible by legitimate means in the design of the chassis and body work, and in the adaptation of the one to the other, the difficulties mentioned are minimized, and a car may be produced with general all-round virtues not otherwise obtainable. It is worthy of note that it is one of the greatest advantages of the combination of a short-stroke engine and worm drive that it permits of engine, gear-box and body work being placed nearer to the ground than in the long-stroke engine and bevel-drive combination.

Suspension Oscillation; Damping.—When a car passes over a culvert or other obstruction the suspension oscillation sometimes persists for several "periods" afterwards; and if a further obstruction, or merely an unevenness of the road surface, occurs during this continued oscillation, fitting in with its phase, the amplitude is liable to cumulative increase. Thus, if there be a more or less regular undulation of the road surface that happens, at the particular speed at which a car is traveling, to fit in with the natural period of its suspension, the amplitude may easily become sufficient to injure the springs or bring some ugly shocks on to the "check buffers" (if any). The only means of avoiding this evil, which is due to synchronization, is to provide some powerful means of damping the oscillations as rapidly as they arise.

It is one of the virtues of the ordinary laminated carriage spring that it possesses to a considerable degree the necessary damping qualities in its own internal friction. When a laminated spring is flexed it is part of the action of such a spring that its constituent elements (plates) slide over one another, and considerable friction results. This friction may be actual solid friction if the spring is not lubricated, or it may be viscous friction if the plates are well greased. In practice the friction is usually of a mixed kind, in part due to the viscosity of some kind of lubricant.

Let us examine the "classic" method of design for the laminated spring. Firstly, since the bending moment is proportional to the distance from the point of application of the load, and the strength is proportional to the number of plates (presuming the latter all of one thickness), the number of plates must be proportioned to the distance from the end of the spring, so that the plates form a series of evenly placed steps. Secondly, assuming the maximum load condition to be that when the plates of the spring are straight, the condition that the plates shall be subject to equal stress is fulfilled when the plates are initially all of equal radius.

When a number of plates of identical radius are "nested" to form a spring they do not fit exactly, for the external curve of the one bears on the internal curve of its neighbor. Under these conditions, when the plates are pulled together by the buckle they bear firmly one on the other, and set up considerable friction, having the required damping effect when the spring is at work.

Now, if, still supposing the spring to be designed for zero camber at maximum load, we construct the spring of plates of different thicknesses, then the correct initial form for such plates will be such that the radius of curvature varies as the thickness, so that if we make the shorter plates thinner than the longer ones the shorter plates will also be of less radius of curvature, and the pressure between the plates when pulled together by the buckle will be greater than when plates of equal thickness are employed.

From the above it would appear that by designing a laminar spring with the plates of different thickness, so that the shorter plates are the thinner, the damping factor of the spring can be improved. In the case when a spring is under negative load, so that the plates are on the point of separating, the damping action vanishes. It will be noted that this point is reached sooner when the spring is designed of plates of equal thickness than is the case if they are graded in the manner above specified.

Worm-Driving and Screw-Propulsion.—In the early days of the screw propeller it was customary to compare it in its action on the water to a screw working in a solid. It was, of course, recognized that the comparison was not one that could be altogether justified, owing to the fact that the fluid in which the screw propeller operates forms a yielding abutment, instead of an unyielding one. At a time when screws were commonly made of true helical form the yielding of the fluid was represented by the factor termed "slip," and this term is used at the present day in a similar sense, although it is now more difficult to define, owing to the pitch angle of a modern propeller varying from point to point over the surface of the blade. Of more recent years

the analogy between the screw working in a fluid and one working in a solid has not been regarded as possessing any serious utility, and it has consequently been neglected; it is only quite recently that my own researches, published in my work on "Aerodynamics," have brought this old analogy up afresh in a new light. In the work in question I have proved that for a blade moving through a fluid, and supporting a pressure reaction, there is a particular relation between the pressure sustained and the square of the velocity of motion at which the total resistance is of least value, and that under these conditions there is a certain gliding angle which is constant in respect of velocity, and whose value is minimum if the correct P/V^2 factor is employed.

The efficiency is given by the expression

$$\frac{\tan \theta}{\tan (\theta + \gamma)},$$

where γ is the angle of friction and θ is the angle of the effective pitch.

The value of θ for greatest efficiency is given by the expression

$$\theta = (90^\circ - \gamma)/2$$

or, in other words, it is equal to 45° minus half the angle of friction in the solid screw.

In Table II. this is shown for different values of γ, together with the corresponding efficiencies, which thus represents the outside limit of the efficiency for a worm-drive.

Table II.—Efficiencies of Worm-Drives.

γ°	θ°	Efficiency.
2	44	0.932
4	43	0.870
6	42	0.811
8	41	0.756
10	40	0.704
12	39	0.655

Gyroscopic Effect of the Flywheel.—The gyroscopic effect of the flywheel of a motor vehicle gives rise, under certain circumstances, to couples of very considerable magnitude.

Employing absolute units, the gyroscopic torque, which we will denote by the symbol τ, is equal to the angular momentum communicated per second—that is,

$$\tau = I \omega \Omega,$$

where Ω is the rate of change of the precessional angle, I the moment of inertia of the flywheel and ω the angular velocity of flywheel.

Let us suppose that a car of 10 ft. wheelbase be traveling at 50 ft. per sec. along a curve of 250 ft. radius; let the flywheel have a mean rim diameter 1.5 ft., that radius of gyration = 0.75 ft., and let the motor speed be 20 revolutions per second; then

$$I = 100 \times 0.75^2 = 56$$
$$\omega = 20 \times 2\pi = 126$$
$$\Omega = 250/250 = 0.2$$

$\therefore \tau = 56 \times 126 \times 0.2 = 1410$ foot poundals,

or torque in pound feet $= \frac{1410}{32} = 47$, or at 10 ft. (wheel base) the force representing the gyroscopic torque is 47 lbs. This, compared to the load carried on the front and rear axles, is almost negligible, amounting to less than half of 1%, taking the total weight of the car as 1 ton.

The speed of the precessional motion is limited in practice, so long as a car is being properly driven, by the fact that the speed at which a given corner can be taken cannot exceed a certain maximum. In the example just given the radius of path is such as can be reasonably negotiated at 50 ft. per second. When, however, a car is driven round a corner above the limiting speed (which happens most frequently when the road is greasy, since then the limiting speed is lower), it is liable to side-slip, and to acquire a rotational speed about a vertical axis, the limiting value of which we have no means of assessing, and the gyroscopic torque may be increased enormously. Thus, supposing in a case of side-slip, a car turn through 180° in one second—a not impossible proposition—we have $\Omega = \pi$,

$$\tau = 56 \times 126 \times 3.14 = 221{,}000,$$

or in pound-feet torque = 22,100/32 = 690; an amount that may put the crank-neck in jeopardy. I believe that several of the mysterious cases of bent cranks have been due to this cause; in some cases it has been definitely observed that a crank has been found bent immediately after a serious side-slip. I have only met with one such case personally, but I make provision for this possibility by strengthening the crank-web next the flywheel, and the neck itself, if there should be any doubt as to its sufficiency. I believe the assumption that a car may, when side-slipping, rotate at a maximum rate of three or four radians (= 170° to 230°) per second, gives a sufficient allowance when calculating for gyroscopic torque.

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Compiled by S. M. WOODWARD*

(CONCLUDED FROM MAY ISSUE.)

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Ringelmann, Maximilien.

Testing Motors, Boats and Automobiles Operated by Alcohol. (Note sur les Moteurs, les Automobiles, et les Bateaux à Alcool du Concours International de 1902.) Bulletin de la Société d'Encouragement pour l'Industrie Nationale, Paris, 101 Année, Tome, 103, Aug. 31, 1902. pp. 201-215. 11 figs. 3500 w.

Illustrates the machines tested, the apparatus used in making the tests, and the results obtained. The testing plant is fully described.

Ringelmann, Maximilien.

Investigations upon Alcohol Motors. (Recherches sur les Moteurs à Alcool.) Comptes Rendus de l'Académie des Sciences, Paris, Tome 125, No. 16, Oct. 18, 1897. pp. 566-569. 1,500 w.

Compares alcohol and gasoline, giving chemical analysis, calorific power, air necessary for combustion, rate of evaporation from free surface, and consumption tests in small gasoline motors of 2 to 4 horsepower, with results showing that the quantity of alcohol required is more than double the necessary quantity of petroleum for the same power developed.

*Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.

Rochat, Octave.

Industrial Alcohol. (Alcool Industriel.) Three articles in the Bulletin Technique de la Suisse Romande, Lausanne, Sept. 25, Oct. 10, 25, 1904. 7500 w.

A study of the applications of alcohol as a source of energy in internal combustion motors.

Rocques, X.

International Exposition of Alcohol Motors and Apparatus. (Exposition Internationale des Moteurs et Appareils Utilisant l'Alcool Dénaturé.) Revue Générale des Sciences, Paris, Tome 13, No. 12, June 30, 1902. pp. 546-548. 2500 w.

A general description of the results obtained at this exposition by the use of alcohol for power, heating and lighting, giving general figures for the consumption of alcohol as compared with other combustibles.

Sartiaux, Eugene and Cossman.

An Alcohol Power Generating Set. (Note sur le Groupe Électrogène a l'Alcool. Utilisé par la Compagnie du Nord pour la Charge des Accumulateurs Alimentant les Cabestans Electriques dans les Petites Stations.) Revue Générale des Chemins de Fer, Paris, 25 Année, 2 sem, No. 3, Sept., 1902. pp. 177-182. 2 figs.

This describes a convenient arrangement of alcohol motor and dynamo used for charging accumulators for operating winches at small stations on the Northern Railway of France.

Schöttler, R.

Alcohol Engines at the Berlin Exposition. 1902. (Die Spiritusmaschinen auf der Ausstellung für Spiritusindustrie in Berlin, 1902.) Zeitschrift des Vereines der Deutscher Ingenieure, Berlin, Bd. 46, Part 1, No. 31, Aug. 2, 1902. pp. 1157-1162. 2500 w.; Part 2, No. 33, Aug. 16, 1902. pp. 1223-1230. 46 figs. 2000 w.

Descriptions and illustrations of different types of German alcohol carbureters, locomobiles, and one marine motor.

A translation of the above into French was printed with the title—Les moteurs à alcool a l'exposition des industries de l'alcool de Berlin, 1902. In the Bulletin de la Société d'Encouragement pour l'Industrie Nationale, Paris, Tome 103, No. 91, Sept., 1902. pp. 414-431.

Sidersky, D.

The Berlin Exposition of the Industrial Uses of Alcohol, February, 1902. (Rapport sur l'Exposition des Emplois Industriels de l'Alcool à Berlin, en Fevrier, 1902.) Annales du Ministère de l'Agriculture, Paris, 21 année, No. 2, June, 1902. pp. 424-440. 4 figs. 4 tables. 5,000 w.

This is the official report of the French representative at the exposition, and describes the uses of alcohol as exemplified for lighting, heating, power production, and in chemical industries and gives statistics on the subject for Germany. Compares first cost and operating expense of alcohol engine of 25 horsepower with other sources of power, and describing the then existing state of development of alcohol engines in Germany.

Sidersky, D.

Industrial Uses of Alcohol. (Les Usages Industriels de l'Alcool.) [Encyclopédie Industrielle.] 16 mo. xii + 408 pp. 92 figs. J. B. Baillière et fils, Paris, 1903.

This work received the Prix Agronomique of the Société des Agriculteurs de France, in 1903. It contains chapters on use of alcohol for lighting, heating, power and automobiles, also in the chemical industries. Various denaturants suitable for use are discussed and also the economic questions involved in the extensive use of alcohol for industrial purposes. Under the use of alcohol for motive power are given a history of the development of the alcohol motor, descriptions of motors and carbureters, results of consumptions tests, and information concerning the use in practice of portable alcohol motors in agricultural operations in Germany.

Sidersky, D.

Supplementary Study on Lighting by Alcohol. (Nouvelle Étude sur l'Eclairage à l'Alcool.) Bulletin de la Société des Agriculteurs de France, Paris, 37 Année, Tome 57, March 1, 1905. pp. 272-277. 3000 w. March 15, 1905, pp. 660-668. 10 figs. 3000 w.

This publication is an abstract from a memoir presented to the society supplementing the memoir by the same author on the industrial uses of alcohol also published separately as a book in 1903. This article discusses the effect upon lamps of impurities in the alcohol, describes and illustrates the construction of various kinds of lamps and gives the consumption and candlepower under test.

Sidersky, D.

Alcohol Motors for Rural Uses. (Les Moteurs à Alcool dans les Exploitations Rurales.) Bulletin de la Société des Agriculteurs de France, Paris, 35 Année, Tome 53, April 15, 1903. pp. 405-418. 7500 w.

This is an extract from the author's extensive memoir entitled "Industrial Uses of Alcohol." This extract contains a historical account of the attempts to use alcohol in internal combustion motors, a summary of the consumption tests of Ringelmann and others, and a discussion of the results collected by Professor Strecker on the actual use of alcohol motors for agricultural purposes in Germany.

Sidersky, D.

Report on the Industrial Uses of Alcohol at the Agricultural Exposition at Halle-on-the-Saal, Germany, June 13-18, 1901. (Rapport sur les Emplois Industriels de l'Alcool à l'Exposition Agricole de Halle-sur-Saale.) Bulletin Ministère de l'Agriculture, Paris, 20 Année, 1901, No. 5. pp. 1061-1107. 22 figs. tables. 16,000 w.

This report discusses the development of the use of denatured alcohol in Germany; the legislation on the subject, the economic conditions existing; the organizations for the production and sale of alcohol; describes and illustrates alcohol lamps, heaters, and engines; gives detailed accounts of investigations on motors in Germany, and shows diagrams illustrating the increasing use of alcohol in Germany since 1887.

Summary and conclusions of this report are given by LUCIEN PERISSE in Memoires de la Société des Ingénieurs Civils de France, Dec., 1901. p. 876. 500 w.

Sorel, Ernest.

Carburation and Combustion in Alcohol Motors. (Carburation et Combustion dans les Moteurs à Alcool.) 8vo. 280 pp. 23 figs. Many tables. Vve. Ch. Dunod, Paris, 1904. (English translation published by J. Wiley & Sons, New York.)

This work gives a complete account and discussion of the tests and experiments conducted by Sorel and Ringelmann in France. Part I. is devoted to a discussion of the combustion of gaseous mixtures, as affected by temperature, pressure, composition of mixture, and proportions of air present. Products of imperfect combustion are discussed. Part II. deals with

carbureters for explosion engines. The requirements for good carbureters are discussed; the characteristics, advantages and disadvantages of the various types are explained and illustrated. Numerous investigations, with specially designed apparatus, were carried out by M. Sorel in establishing the laws controlling the various phenomena occurring in carbureters. These investigations are fully described and the results are given. Part III. deals with the various dissociation phenomena taking place in alcoholic gaseous mixtures, at different temperatures, as affected by the presence of oxygen and the various metals.

Sorel, Ernest.

Report on the Liquid Fuels Used in the Alcohol Competition of October and November, 1901, at Paris. (Concours Général de Moteurs et Appareils Utilisant l'Alcool Dénaturé. Rapport de la Commission Mixte des Liquids.) Annales du Ministère de l'Agriculture, Paris, 21 Année, No. 1, April, 1902. pp. 164-173. 4 tables. 2500 w.

This is the official report of the chemical determination of the fuel used in the Paris competition of 1901. The report of the first section of the "Concours" is referred to in this bibliography under RINGELMANN, MAXIMILIEN; of the second section, under LINDEL, L.

Sorel, Ernest.

The Phenomena of Combustion in Stationary Alcohol Motors. (Sur les Phénomènes de la Combustion dans les Moteurs Fixes à Alcool.) Revue de Mécanique, Paris. Serial.

Part I., Tome 12, No. 1, Jan. 31, 1903, pp. 33-49, 6 figs., 5 tables, 6000 w., describes methods and gives results of chemical analyses of fuels used at Paris exhibition of May, 1902, also results of analyses of exhaust gases, and results of examination of engine valves.

Part II., Tome 12, No. 2, Feb., 1903, pp. 125-148, 4 figs., 8 tables, 9000 w. This part includes a study of the chief compounds in gasoline and a study of the temperature-vapor tension curves of alcohol pure and with various denaturants, all considered in their bearing on the necessary form of carbureters.

Part III., Tome 13, No. 1, July, 1903, pp. 5-16, 2 figs., 3 tables, 3500 w. A discussion of different types of carbureters with reference to their suitability to the use of alcohol.

Part IV., Tome 13, No. 2, Aug., 1903, pp. 122-148, 4 figs., 4 tables, 8000 w. This concludes the study of types of carbureters.

These articles appear to be an official report to the Minister of Agriculture, dated Jan. 18, 1903. The matter was largely reprinted later in the author's book on the subject.

A reference to a discussion of this report is given in this bibliography under LONGRIDGE, C. C.

Sorel, Ernest.

Hydrocarbons for Mixing with Alcohol. (Les Carburants de l'Alcool.) Comptes Rendus du Congrès de l'Alcool, Paris, 1903. pp. 56-61. 3000 w.

A discussion of the properties of the various substances available for mixing with alcohol to obtain a mixture of high heating power.

Strecker.

Data on the Operation of Portable Alcohol Engines in Actual Practice. (Die Spirituslokomobilen und Erfahrungen über Ihre Leistungen in der Praxis.) Hildesheimer Land und Forstwirtschaftliches Vereinsblatt, Vol. 41, No. 9, March 1, pp. 131-135, and No. 10, March 8, 1902, pp. 148-153.

This was an address delivered in Hildesheim, giving the substance of the reports received from 120 users of portable alcohol engines in agricultural operations. The cost of operation, maintenance and general reliability of these engines in practical use are discussed in detail.

The substance of this address is included in Sidersky's "Les Usages Industriels de l'Alcool."

T.

Fuel Tests of Automobiles. (Épreuves de Consommation pour Voitures Automobiles.) Le Génie Civil, Paris, Tome 40, No. 21, March 22, 1902. pp. 349-350. 5 tables. 1200 w.

Data and results of various trials with special reference to internal combustion motors using alcohol and gasoline. Includes the consumption in liters of fuel per ton-kilometer in the competition of 1900 using gasoline, in the Paris-Rouen contest October 28, 1900, using 50 per cent. mixture of alcohol and gasoline, in the Paris-Roubaix contest April 7 and 8, 1901, using alcohol gasoline mixture, in the Suresnes-Corbeil contest, February 5, and March 5, 1902, using alcohol gasoline mixture and pure gasoline.

Tedesco, N. de.

The French Alcohol Competition of 1901. (Le Concours General pour l'Utilisation de l'Alcool.) La Revue Technique, Tome 22, No. 22, Nov. 25, 1901. pp. 514-515. 2000 w.

This article deals with the lighting and heating apparatus exhibited and the alcohol motors operated. The different carbureters are named and classified; Oelker's German experiments on the thermal efficiencies of steam, kerosene, gasoline, and alcohol are quoted; table of Arachequesne is given on first cost and running expenses with steam, kerosene, gasoline and alcohol, as also the similar results obtained in France by Loreau.

Trillat.

Denaturing Alcohol and a Study of Various Denaturants. (Procédés de Dénaturation et Étude des Divers Dénaturants.) Comptes Rendus du Congrès de l'Alcool, Paris, 1903. pp. 61-69. 4000 w.

A discussion of the qualities which should be possessed by alcohol denaturing materials, and of the various available materials possessing these qualities.

Tyrer, Thomas.

The Need of Duty-free Spirit for Industrial purposes. Journal of the Society of Arts, London, Vol. 52, No. 2684, April 29, 1904. pp. 504-537. 19 tables. 27,000 w.

An extensive statistical and economic study of the use of alcohol in the arts, but touching only slightly upon its use for the development of power.

United States—Congress, 59th, 1st Session—House Committee on Ways and Means. Free Alcohol. Hearings before the Committee on Ways and Means of the House of Representatives, 59th Congress, 1st session, February and March, 1906. Government Printing Office, Washington. 439 pp.

This is the complete report of the testimony taken at the hearings.

Vialettes, A.

Report on the Montpellier Alcohol Competition. (Rapport sur le Concours de l'Alcool Dénaturé, Appliqué aux Usages Industriels Chauffage, Éclairage, et Force Motrice, Organisé à Montpellier par la Société Départmentale d'Agriculture.) La Revue Technique, Tome 24, No. 16, Aug. 25, 1903, pp. 553-557, 5000 w., and No. 17, Sept. 10, 1903, pp. 598-599, 1500 w.

This is a detailed discussion of all the exhibitions and researches dealing with industrial alcohol up to the date of the report.

Viger, M.

The International Alcohol Exposition Held at Vienna in 1904. La Revue Technique, Tome 25, No. 19, Oct. 10, 1904. pp. 1037-1039. 2500 w.

A report made at a meeting of the National Society of Agriculture in France, describing the organization and successful carrying out of the Vienna alcohol exhibition.

Wittelshöfer, P.

Spirit Lighting. (Éclairage à l'Alcool.) Uber Spiritus-Beleuchtung. Ergänzungs-Heft zum Katalog der Austellung für Gärungsgewerbe zu Berlin, May 29-June 7, 1903. Berlin, P. Parey, 1903.

English version, pp. 101-112, French version, pp. 45-56 of the French-English edition. German version, pp. 48-58 of the German edition.

A lucid discussion of the value and merit of alcohol for lighting as compared with other illuminants.

Wiley, H. W.

Industrial Alcohol: Sources and Manufacture. Farmers' Bulletin, No. 268, U. S. Dept. of Agriculture. 45 pp. 10 figs.

Wiley, H. W.

Uses and Statistics Farmers' Bulletin, No. 269. U. S. Dept. of Agriculture. 29 pp. 10 figs.

A popular treatment of the subject, giving useful information including a discussion of the use of alcohol for heating and lighting.

Anonymous Articles (Arranged chronologically).

Alcohol Motors. (Les Moteurs à Alcool.) Mémoires de la Société des Ingénieurs Civils de France, Paris, Année 1898, 1 Vol. No. 1. p. 117. 400 w.

Quotes the results of experiments by Ringelmann, comparing consumption of alcohol, gasoline and kerosene when used in the same internal combustion engine. Also gives results obtained in Germany on a motor made by Koerting Bros., of Hannover.

Alcohol Motor Car Trials in France. Engineer, London, Vol. 92, Nov. 8, 1901. pp. 475-476. 5 illustrations of motor cars. 3200 w.

Describes the trials then being conducted by the French Minister of Agriculture with the object of increasing the consumption of alcohol. Gives also the numerical results of the French road trials to determine the economy of the use of alcohol.

The French Alcohol Carriage Trials. Autocar, Coventry, Eng., Nov. 9, 1901. 1500 w.; illustrated.

A brief account of trials in the neighborhood of Paris for obtaining official data upon the economy of alcohol and its utilization.

Alcohol and Automobiles. What the French Government is Doing to Make Spirits Replace Gasoline. Motor World, New York, Vol. 3, No. 8, Nov. 21, 1901. pp. 223-224.

Reprinted in Scientific American Supplement, New York, Vol. 53, No. 1360, Jan. 25, 1902; pp. 21797-21798; 1400 w.

A discussion of the various French tests of alcohol in automobiles.

The French Alcohol Motor Trials. The Engineer, London, Vol. 92, Nov. 22, 1901. p. 535. 1500 w.

Gives numerous detailed results of tests at the French trials of 1901, and discusses briefly the difficulties of the use of alcohol in motors and costs.

Alcohol Automobiles at the Paris Alcohol Exhibition [1901]. Scientific American, Dec. 28, 1901, Serial, Part I. The Gobron-Brillié. Vol. 85, No. 26, Dec. 28, 1901. p. 428. 3 figs. 800 w.

This gives a history of the experiments in developing the use of alcohol for power. A half-tone illustration of a 12 horsepower alcohol Gobron-Brillié tonneau, a diagram section through the carbureter and two sectional views of the engine are shown. There is a full description of the working of the carbureter and of the governing of the fuel supply. Part II., The Bardon. Vol. 86, No. 3, Jan. 18, 1902, pp. 37-38, 2 figs., 400 w. Describes and illustrates the Bardon carbureter and automobile for pure alcohol. A sectional diagram of carbureter and a picture of the automobile are shown.

Alcohol in the Industries. (L'Alcool per le Industrie.) L'Industria, Milan, Jan. 5, 1902. 2500 w.

This is the report of the commission of the Italian government upon the proposed methods of using denatured alcohol for heating and motive power.

French Spirit Motors. Engineering [London]. Vol. 73, No. 2, Jan. 10, 1902. pp. 45-48. 5 figs.

An account of the steps taken in France and Germany to use alcohol for driving motors and for lighting and heating purposes. Discusses also the construction of alcohol motors.

Official Tests of Alcohol Motors. Scientific American, New York, Vol. 86, No. 2, Jan. 11, 1902. p. 23. 800 w.

A description of the tests and table of results of the French automobile tests using alcohol, in the autumn of 1901, made at Paris by a commission of experts under the direction of the Minister of Agriculture of France.

The Problem of Alcohol. Automotor and Horseless Vehicle Journal, London. Vol. 6, No. 65, Feb., 1902. pp. 203-205. 2500 w.

A discussion of the applicability of alcohol to the operation of explosion engines and of the experiments made in France and other countries.

Reprinted in the Scientific American Supplement, New York, Vol. 53, No. 1373, April 26, 1902. pp. 22001-22002, under the title: "The Problem of Alcohol for Motive Power."

The Manufacture and Technical Uses of Alcohol in Germany. U. S. Consular Reports, Advance Sheets, No. 1288, March 13, 1902. 10 pp. 6 figs. 2200 w.

This contains an account of the special exposition at that time being held in Berlin, and gives illustrated descriptions of various interesting exhibits, including alcohol motors, and different forms of heating and lighting apparatus.

The Manufacture and Technical Uses of Alcohol in Germany. Scientific American Supplement, New York, Vol. 53, No. 1370, April 5, 1902. pp. 21958-21959. 1600 w.

A description of the Berlin alcohol exposition held February 8 to March 16, 1902.

Lamps, Burners and Heating Apparatus at the Paris Alcohol Exposition. Scientific American Supplement, New York, Vol. 53, No. 1376, May 17, 1902. pp. 22048-22050. 12 figs. 3200 w.

Illustrated descriptions of various lamps with results of consumption tests on some of them. The

illustrations and descriptions obtained from the following articles: PERISSE, LUCIEN. Exposition de l'Alcool: Eclairage et Chauffage. La Nature, Paris, 30 année, 1 sem., No. 1491, Dec. 21, 1901, pp. 35-37. 3 figs., and GUERIN, H., Concours et expositions de moteurs utilisant l'alcool dénaturé; Eclairage et chauffage. Le Génie Civil, Tome 40, No. 6, Dec. 7, 1901, pp. 88-92; No. 7, Dec. 14, 1901, pp. 104-106. 20 figs.

Trials of Alcohol Motors. The Engineer, London, Vol. 93, No. 2421, May 23, 1902. p. 504. 2500 w.

Gives descriptions of the 20 motor vehicles completing the trial course from Beauvais to Paris, 59 miles, and the consumption of fuel, which was a mixture of alcohol and benzine.

The Northern Alcohol Race. Autocar, Coventry, Eng., May 24, 1902. 4600 w.

An account of this road race in northern France, which proved that alcohol could be used satisfactorily for vehicles running at high speeds.

The French Alcohol Tests. (Circuit du Nord.) Automotor and Horseless Vehicle Journal, London, Vol. 7, No. 7, May 31, 1902. pp. 172-175. 3000 w.

An account of the racing tests and results, and of the consumption trials and results. Also a brief mention of the Paris alcohol exhibition, held under the direction of the Minister of Agriculture of France, May 1902.

The French Alcohol Automobile Endurance Test. Scientific American, New York, Vol. 87, No. 2, July 12, 1902. p. 19. 600 w.

A brief account of the endurance run of 571 miles in northern France, of the alcohol consumption test over 452 miles, and the second international Paris exposition of alcohol automobiles and stationary motors in May, 1902.

Carbureters at the Paris Alcohol Show. Automotor and Horseless Vehicle Journal, London, Vol. 7, No. 8 (No. 74), June 7, 1902. pp. 200-201. 5 figs. 1200 w.

Brief illustrated descriptions of various carbureters.

The International Exhibition of Alcohol Motors. Scientific American Supplement, New York. Vol. 54, No. 1391, Aug. 30, 1902. p. 22289. 2 figs. 2000 w.

A description of the second international exhibition of alcohol motors, organized by the French Minister of Agriculture, May, 1902.

Report of the Congress for the Economic Study of the Industrial Uses of Alcohol Held March 11-17, 1903. (Congrès des Études Économique pour les Emplois Industriel de l'Alcool. Comptes Rendus des Séances.) Paris, 1903. Imprimerie National, République Française, Ministère de l'Agriculture. 376 pp. Many tables. 3 plates.

This report gives many papers read at the congress, dealing with legislation, statistics, sources and production of alcohol, cost of production and denaturing. The most valuable papers relating to the consumption of alcohol by burning are: An economic study of the comparative value of alcohol and other sources of power by M. Chaveau; Hydrocarbons for mixing with alcohol by Ernest Sorel; Denaturing alcohol and a study of various denaturants. The report includes the French laws then existing relating to the use of denatured alcohol, by M. Trillat.

Report of the Congress on the Uses of Denatured Alcohol Held in Paris, December 16-23, 1902. (Congrès des Applications de l'Alcool Dénaturé. Rapport et Comptes Rendus.) Automobile Club de France, 1903. 372 pp., 118 figs. and numerous diagrams.

This report contains many papers and discussions on the use of alcohol, among the more important of which are: Alcohol carbureters by L. Périssé and H. de la Vallette; Use of carburated alcohol in a Brillié motor, by Eugène Brillié; and a contribution to the theory of alcohol engines by G. Chaveau.

Alcohol Engines. The Engineer, London, Vol. 95, Feb. 13, 1903. pp. 169-170. 900 w.

An editorial discussion of Sorel's report on the French tests of May, 1902, dealing with the effect of alcohol on the engine valves, and the chemical analyses of the exhaust gases.

The Use of Alcohol as Fuel and Illuminant. Scientific American Supplement, New York, Vol. 55, No. 1425, April 25, 1903. p. 22840. 3 figs. 1200 w.

Relates to apparatus shown at the exhibition of the Automobile Club of France.

Alcohol on the Prussian State Railways. The Engineer, London, Vol. 95, May 1, 1903. p. 447. 400 w.

Summarizes a report by the German Minister of Public Works on the employment of denatured alcohol for motive purposes and for light, especially comparing the cost with oil.

Heating and Lighting Apparatus for Use with Denatured Alcohol.

Numerous brief descriptions of apparatus appeared in La Revue Technique during a considerable period of time and are here listed together:

Heating and Cooking Apparatus. Tome 24, No. 13, July 10, 1903. pp. 433-435 5 figs. 1800 w.

Projection Lantern. Tome 24, No. 14, July 25, 1903. pp. 463-465. 3 figs. 1200 w.

Projection Lanterns. Tome 24, No. 16, Aug. 25, 1903. pp. 551-553. 4 figs. 1800 w.

Lamps. Tome 24, No. 17, Sept. 10, 1903. pp. 593-596. 3 figs. 2500 w.

Projection Lanterns. Tome 24, No. 18, Sept. 25, 1903. pp. 633-634. 2 figs. 1000 w.

Alcohol Lamps. Tome 24, No. 6, March 25, 1903. pp. 161-164. 3 figs. 2500 w. Tome 24, No. 19, Oct. 10, 1903, pp. 675-677. 3 figs. 1500 w. Tome 24, No. 20, Oct. 25, 1903. pp. 719-721. 2 figs. 1800 w. pp. 722-723. 1 fig. 1200 w. Tome 24, No. 21, Nov. 10, 1903. pp. 763-764. 6 figs. 1500 w. Tome, 24, No. 22, Nov. 25, 1903. pp. 807-808. 1 fig. 900 w. Tome 24, No. 24, Dec. 25, 1903. pp. 895-896. 1 fig. 1000 w.

Laboratory Apparatus. Tome 25, No. 1, Jan. 10, 1904. p. 35. 700 w.

Motor Cars in Paris. The Engineer, London, Serial, Part V., Vol. 97, No. 2508, Jan. 22, 1904. p. 87. 1 fig. 1100 w.

Discusses similarity of conditions to be secured in successful carbureters for alcohol and kerosene, and difference from gasoline. Emphasizes necessity for special design of engines and carbureters in order to secure high efficiency with alcohol. Describes and illustrates Longuemare carbureter.

Part VI., Vol. 97, No. 2509, Jan. 29, 1904. p. 104. 3 figs. 2000 w. Describes and illustrates Brouhot alcohol carbureter, also the Gobron-Brillié alcohol engine which simply sprays its alcohol charge without heating, but nevertheless secures high economy in comparison with gasoline, according to test results which are given.

Yearbook of the German Alcohol Manufacturers. (Jahrbuch des Vereins der Spiritus-Fabrikanten in Deutschland.)

This annual volume, begun in 1901, contains each year several hundred pages and gives brief accounts of tests of engines, heating and lighting apparatus, but deals chiefly with statistics and methods of alcohol manufacture.

Carbureters. (Étude sur les Carburateurs.) La Revue Technique, Tome 26, No. 12, June 25, 1905. p. 506. 8 figs. 3500 w.

This article describes and illustrates several forms of carbureter suitable for alcohol and other liquid fuels.

Denatured Alcohol. U. S. Daily Consular and Trade Reports, No. 2633, Aug. 6, 1906. 9 pp.

Gives information regarding the production, price, sale, and use of denatured alcohol in Italy, France, Germany, Cuba and Belgium.

THE GOVERNING AND THE REGULARITY OF GAS-ENGINES*

By JAMES ATKINSON

The continuous increase in the size of gas-engines and the widening field for their employment have necessitated various modifications in their design and methods of operation, the question of their regularity of turning and closeness of governing being by no means the lease important causes of these modifications. It is very usual to hear remarks made as to the irregularity of gas-engines, as though they were usually and necessarily more irregular than steam-engines, such remarks being very unfair. It is true that the cyclical variations of speed may be slightly greater in the ordinary single-cylinder "Otto" gas-engine than in the case of the ordinary steam-engine; but the mean variation is usually considerably better, and even with hit-and-miss governing, such engines are amply steady enough for ordinary shop-driving, pumping, and the great majority of purposes for which power is required. Even for electric-light driving, ample steadiness can be obtained by using a sufficiently heavy fly-wheel.

Methods of governing gas-engines may be divided into two classes. In the first class the volume of the charge remains constant and sufficient to fill the cylinder as nearly as possible at atmospheric pressure, but the proportion of gas to air is varied according to the load. In the second the proportion of gas to air is kept approximately uniform, but the volume of the charge is varied either by closing the admission valve before the end of the suction-stroke or by throttling; the result in either case being a charge sufficient to fill a part of the cylinder only at atmospheric pressure. The first method is commonly called the "quality" method, and the latter "quantity" method.

The most desirable arrangement to use depends to a large extent on the size and type of engine, also on the kind of gas employed. It is desirable to use the quality type with engines having any considerable weight of reciprocating parts attached to one connecting-rod, because under these circumstances the inertia of the reciprocating parts should be cushioned by the compression pressure in the cylinder at the time of ignition, otherwise shock may be caused similar to that in a steam-engine working with insufficient compression or lead. Either the quality or quantity method is applicable to engines having only one piston attached to the one connecting-rod and running at a moderate speed, as under these circumstances the reduced compression pressure is sufficient to take up the inertia forces and to prevent shock at the time of ignition. When some kinds of producer gas are used it is necessary to have governing appliances which are not liable to be upset by a little tar or dust in the gas.

The quality method may be subdivided into hit-and-miss governing, variable gas-admission uniform during the suction-stroke, and variable gas-admission caused by opening the gas-valve earlier or later during the suction-stroke, but always closing it at the end of this stroke, the contents of the cylinder when reduced loads are being carried being to some extent stratified, air being next to the piston and a rich mixture drawn in last, remaining near the firing-point.

The quantity method of governing may be divided into throttle governing and cut-off governing. With one or two unimportant exception all types of governing are included in the above.

For many years hit-and-miss governing was universally and exclusively employed, and it still remains the usual method for small or moderate sized engines. So far as the author is aware, its economy has practically never been excelled, being only equalled on full loads by very carefully arranged methods, and on

*From a paper read before the Institution of Mechanical Engineers, April 10, 1908.

light loads it is still necessary to combine hit-and-miss governing with other methods to obtain such results.

As usually constructed the governor decides whether there is to be a hit and a miss by the fact of one knife-edge passing on one side or the other of a second knife-edge, practically by a hair line, and the same hair line on all loads; the governor itself therefore always governs when in one position, and it does not much matter if it is very far from being isochronous; also, as it has very little actual work to do, the parts to move being very light and there being scarcely any resistance to overcome, a very small governor will effectually control a large engine. The closeness of governing, or the mean variation of speed, on varying loads with an engine having a fairly heavy fly-wheel can easily be kept within 2% from full load to any load. Most gas-engines fitted with hit-and-miss governing are arranged so that if the engine pulls up on the load from any cause, the operating gear for opening the gas-valve is drawn out of contact as the engine slows down and before it stops, thus the engine cannot stop with the gas-valve open. This precaution is absolutely necessary for the safety of engines liable to be left for long periods by the attendant, and drawing their air charges from the engine room.

The ordinary hit-and-miss gear is well known, but a recent improvement may be described. It consists in allowing the blade of the pusher a small amount of side play at right angles to the line of thrust, so that the knife-edge may always find the bottom of the V in the die in whatever position the latter may be held in the governor rod. When disengaged, the blade rests in the V of the fixed block and naturally slides to the bottom thereof, thus returning to its proper position should it have been deflected sideways by the motion of the die. The deflections, without this improvement, though small, often cause corresponding movements of the governor, and occasionally nibbling or partial opening and sudden flying back of the gas-valve, accompanied by needless wear and tear, objectionable noise, and sometimes irregular explosions in the cylinder.

There is a tendency in some quarters to belittle hit-and-miss governing, but for many purposes, especially in small engines, it still remains the most suitable arrangement, and it is advisable to give due weight to the solid and substantial advantages it offers before substituting other arrangements.

Quality-governing by admitting the gas in varying quantities continuously throughout the suction-stroke is not generally adopted, though some very large engines have been controlled in this manner. The extent to which variation in richness of the mixture can be carried out in this way is somewhat limited. If the charge is either too rich or too weak, it will not ignite freely, but will burn slowly, and in either case a point is very soon reached when it burns so slowly as to continue still inflamed during the whole of the exhaust-stroke, and until the commencement of the suction-stroke, when the fresh charge drawn into the cylinder is fired by the smouldering flames still lingering there, and an explosion takes place whilst the admission-valve is still open, resulting in burnt products being driven into the air and gas mains, sometimes causing the next or second charge to be vitiated, so that two full working strokes are occasionally spoiled in this way.

When the engine is always working on full load, or almost full load, this method of governing can be used successfully, but for engines which have to govern throughout the full range of work from full load to no load it is not satisfactory. It has, however, the advantage of simplicity. A very common arrangement is to have two throttle-valves, one in the air-main and one in the gas-main, controlled by the governor which closes one as it opens the other, and vice versa. As these throttle-valves can be arranged to be in equilibrium, the governor need not be very powerful. In small or medium-sized engines the addition of a gas-valve and hit-and-miss governing, to come into operation so as to miss occasionally when the engine is running below half load, makes a great improvement to this type of governing, by preventing the irregularities which might otherwise occur on these light loads and also the excessive gas consumption. Unfortunately, hit-and-miss governing is scarcely suitable for large engines, owing to the inadvisability of opening a large and necessarily heavy gas-valve by means of a knife-edge.

Variable gas admission caused by opening the gas-valve earlier or later during the suction-stroke, but always closing at the end of this stroke, is a method of governing which is of recent years rapidly coming into use, and is a most satisfactory method, at any rate for large gas-engines. By admitting the air and gas in this way when working on light loads, air only is first drawn in, the gas being ad-

mitted towards the end of the suction-stroke; the result is that part of the charge next to the piston does not contain any gas, or only a very small proportion, but the part near the ignition point has sufficient to make it freely ignitable, there being what is known as stratification throughout the cylinder during both the suction and the compression strokes. In the earlier days of gas-engines Mr. Frank Crossley perfected a method of applying this principle to the smaller engines made in those days by means of a stepped gas-cam for opening the gas-valve, the various steps causing the gas-valve to be opened earlier or later according to the power required, but always closing with the air.

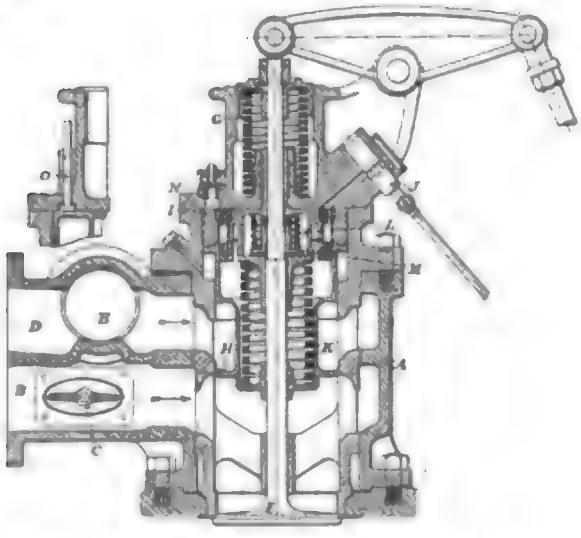

FIG. 1.—THE CROSSLEY GOVERNING GEAR.

A very considerable proportion of the large gas-engines recently made have been governed in this manner, including all of the Oechelhäuser and Körting types, in which it is practically necessarily adopted. Also a very large number of double-cylinder engines, which unavoidably have considerable inertia in the reciprocating parts.

The author's firm having recently constructed some tandem engines of 500 to 600 HP., the question as to the method of governing them had to be considered.

A novel type of governor was adopted, the arrangement of the gear being shown in Fig. 1. Referring to Fig 1, a main casting, A, is fixed on the top of the cylinder in which the valve proper is inserted. It has an air connection B, containing a throttle-valve C, which is fixed definitely in one position to suit the gas which is being used, also a gas connection D, containing a gas-cock E, which serves to regulate the gas. The admission valve F is opened at the commencement of each suction-stroke by means of a cam-rod and lever in the usual manner, being closed by a spring G at the end of the suction-strokes. The gas valve H is centered on the spindle of the valve F, and has attached to it at its upper end a vacuum piston I; the admission of air, either freely, partially or its non-admission to the vacuum cylinder, is controlled by a cylindrical plug J, having a groove turned in it which opens or closes the air connection. The position of this plug J is decided by the governor, a movement of about ½ in. controlling the speed of the engine from full load to no load. Acting on the gas valve there is a nut M, which forces the vacuum piston I to the end of its upward stroke whenever the admission valve F is closed, being assisted finally by a strong buffer spring L. When the valve F is closed, it will be seen that the spring K is neutralized; as soon as the valve F commences to open, the pressure of this spring at its upper end is taken by the nut M, which is screwed on the spindle of the valve F, and the pressure at the lower end tends to open the gas valve H. If the plug J allows free access of air to the vacuum cylinder, the gas valve H moves with the valve K, and also closes with it, allowing a uniformly rich charge to be drawn into the cylinder during the whole of the suction-stroke, thus giving full power impulses. If, however, the plug J closes the communication from the atmosphere to the vacuum cylinder, the vacuum in the cylinder prevents the gas valve H being opened, a few pounds vacuum in this cylinder being amply sufficient to overcome the power exerted by the spring K; under these circumstances no gas is admitted during the suction-stroke, but as the air passage B is freely open, air only is drawn into the cylinder and there is no impulse; this represents two extremes, which in practice rarely occur, as the plug J is usually in such a position as to give a more or less restricted admission of air, causing a partial vacuum in the vacuum cylinder at the commencement of each suction-stroke, this partial vacuum, restraining the opening of the gas valve, making it open later and more slowly; it, however, catches up to the main admission valve and always closes with it, consequently air only to a greater or less extent is drawn in first and a rich mixture at the last. There is a small snifting valve N opening outwards from the vacuum cylinder, which always ensures the prompt return of the valve F in closing.

It will be seen that all the governor has to do, when governing a tandem-engine having

two single-acting cylinders, is to move two small cylindrical plugs which are an easy sliding fit in their cylinders, the plugs themselves being always in equilibrium, with the result that prompt and certain control is always ensured. The vacuum-pistons, the springs, and the other moving parts are all enclosed and shut off from communication with the gas, consequently any tar or dust in the gas can only gain access to the gas-valve, which is so constructed that its movement cannot be clogged; the mechanical parts are also constructed so that any wear will be infinitesimal. The actual operating medium is atmospheric air, which is costless and indestructible.

A short time ago an engine fitted with these valves was tested by Dr. Nicolson, Professor of Engineering at the Municipal School of Technology, Manchester.

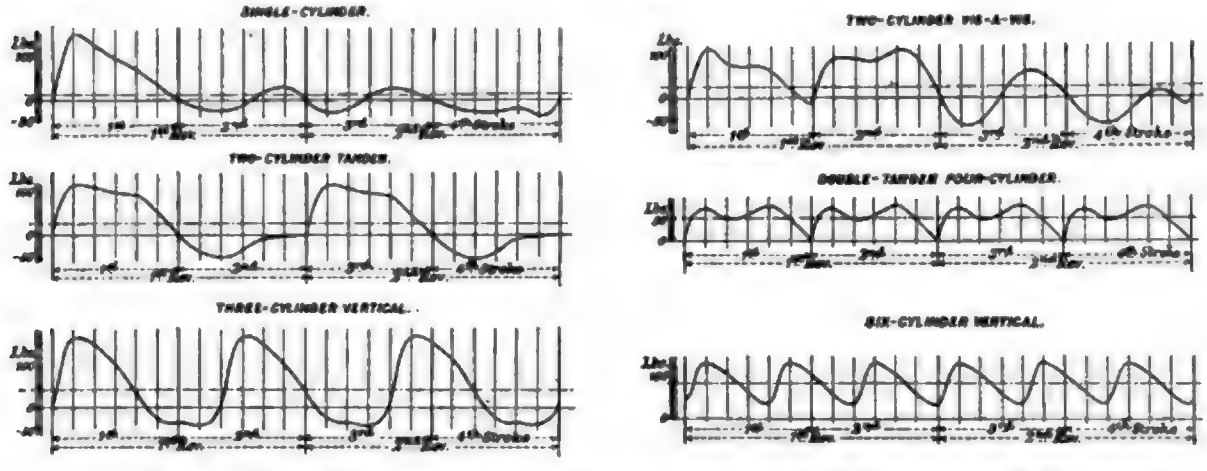

FIG. 2.—TANGENTIAL TURNING EFFORTS ON GAS-ENGINE CRANK-PINS.

The engine speed varied only from 119.4 to 121.4 revolutions per minute when the horsepower was instantaneously dropped from about 600 to about 50. The total variation in speed was therefore 1 2/3% of the mean speed. The full load was then thrown on again as quickly as possible, and so on in succession. The speed of the engine under such circumstances never varied more than the above percentage. No back-firing of any kind took place.

A further advantage of this gear is that it is perfectly noiseless, with the exception of a slight hissing noise due to air entering and leaving the vacuum cylinders.

The gas used was made from bituminous coal in a Crossley plant.

The gas was tested in a Junker calorimeter during the time of the test, the gas being taken from close to the inlet to the engine; the result was 149 B. T. U. per cu. ft. on the lower scale, at atmospheric temperature and pressure, according very closely to the heat value given by the analysis. The engine was running on a brake load of 559 HP., the gas consumption per B. HP. reduced to 0° C. and 760 mm. was 51.94 cu. ft. per B. HP.-hr. The heat supplied was therefore 8,128 B. T. U. per B. HP.-hr. The thermal efficiency on the brake was therefore 31.32%. (I. HP. = 613.6; thermal efficiency on the I. HP. = 35.6%.) So far as the author is aware, this is the highest efficiency that has been obtained in a large gas-engine in any well-authenticated trial.

Good governing is only one of the requirements in gas-engines: when extreme regularity is necessary, more than one cylinder and heavy fly-wheels containing a considerable amount of inertia are also needed.

In designing gas-engines to make them so that they will not exceed a definitely stated amount of irregularity, careful estimates have to be made as to the effect of the number and disposition of the cylinders, the power of the impulses, the inertia in the fly-wheel, the effect of the inertia of the reciprocating parts and of the compressions. A number of curves have been carefully prepared for the different arrangements in common use and under ordinary conditions. Some of these curves are shown in Fig. 2. The author is aware that somewhat similar curves have been given in different publications, but not in a form in which they could be used conveniently.

The cylinders in all instances are assumed to by single-acting, 18 ins. in diameter and 2-ft. stroke, and working with a mean pressure of 88.2 lbs. The compression pressure is 180 lbs. and the mean pressure during compression is 37.2 lbs. The total force exerted during a working stroke in any cylinder is thus that corresponding to a mean pressure of 88.2 +

37.2 = 125.4 lbs. per square inch of the piston.

The net power resulting from one impulse is:—

$$\frac{88.2 \times 254.5 \times 2}{2240} = 20.04 \text{ ft.-tons.}$$

For the purpose of enabling direct comparison between the various types of engines to be made, they are all assumed to be fitted with fly-wheels which have thirty impulses of kinetic energy in them when running at their mean speeds; that is to say, $20.04 \times 30 = 601.2$ ft.-tons.

1.	2.	3.	4.	5. deg.
Single cylinder..	1	106.3	1/49.9	1.8
Vis-à-vis	1.29	138	1/38.5	2.33
Tandem	0.836	88.6	1/59.7	0.75
Double tandem..	0.129	13.75	1/383.3	0.06
Three cylinder..	0.716	76.17	1/69.5	0.42
Six cylinder....	0.144	15.5	1/338.3	0.044

The table above gives in column 1 the type of engine. In column 2 the areas between the curves of turning efforts and the mean working lines from which the excess or the deficiency of work done can be estimated, these areas being given relatively to a single-cylinder engine which is taken as 1. Column 3 gives the mean pressure per sq. in. on the piston throughout a working stroke which would give an amount of power corresponding to the excess or to the deficiency. Column 4 gives the speed variation expressed according to the formula $\frac{\text{Maximum} - \text{Minimum}}{\text{Mean}}$, assuming that the kinetic energy in the fly-wheel at mean speed is 30 impulses. Column 5 gives the difference in degrees the fly-wheel of the engine would be ahead of, or behind, a wheel of constant speed.

The particulars given in the table are obtained in the manner described below; the figures for the single-cylinder engine being worked out, and those for the other types in a similar way. In the case of the single-cylinder engine the area of curve above the mean power line during the first stroke, corresponds to a mean pressure of 67.67 lbs. per square inch of piston referred to the full movement of the crank-pin for this working stroke and

$$\frac{67.67 \times 3.1416}{2} = 106.3.$$

Thus the excess of power in this engine having a cylinder 18 in. × 2 ft. is

$$\frac{106.3 \times 254.5 \times 2}{2240} = 24.15 \text{ ft.-tons,}$$

and this amount is added to the kinetic energy in the fly-wheel every impulse, accelerating its speed from its lowest to its highest speed. One-half the amount of 24.15 tons, or 12.075 ft.-tons added to or subtracted from the mean kinetic energy of 601.2 ft.-tons is 613.275 ft.-tons maximum and 589.125 ft.-tons minimum kinetic energy. The speed of the fly-wheel will vary in proportion to the square roots of these energies, or in the ratio of 24.764 to 24.273, the mean of these being 24.518, and the difference 0.491; the fraction

$$\frac{0.491}{24.518} = \frac{1}{49.95}$$

will represent the speed variation in this engine according to the formula

$$\frac{\text{Maximum} - \text{Minimum}}{\text{Mean}}.$$

Irregularities in speed cause the fly-wheel of the engine to get ahead of, or behind, absolute uniformity. In a single-cylinder engine of the Otto type it passes from its most retarded position to its most advanced position and back again during the time the crank is making two revolutions and passing through 720°. Twice during this 720° the fly-wheel is moving at the speed corresponding to absolute regularity, and when gaining on, or losing on, this speed it moves at a mean of $\frac{1}{49.95 \times 2}$ times the mean speed of the fly-wheel, plus or minus this speed; consequently $\frac{720°}{49.95 \times 2 \times 2 \times 2}$ will give the total distance in degrees that the fly-wheel varies from uniformity, and half this will be the amount which the fly-wheel is ahead of or behind it. In this case $\frac{720°}{49.95 \times 2 \times 2 \times 2} = 1.8°$.

The figures for the other types of engines given in the table are obtained by similar calculations; in the figures given in the fifth column, however, it is necessary to bear in mind that the 720° applies to the vis-à-vis type as well as the single-cylinder engine, owing to the fact, as shown in its curve, that the acceleration continues during two consecutive strokes (the small area in between has to be deducted); in all the other instances the 720°

requires also to be divided by the number of cylinders.

Speed variation is the important factor when considering gas-engines as employed for most purposes, but for the special purpose of driving alternators in parallel, also for some other uses, speed variation is only one of the factors which have to be considered; it is necessary to combine it with a time element, and thus obtain the position variation—a point which is very frequently overlooked in this connection. It will be seen by comparing columns 4 and 5 that there is a very considerable difference in the relative variations of the different types of engines, and yet it is most unusual for anyone to ask for anything but speed variation when inquiring about an engine.

A notable feature emphasized by the table is the excellent result which can be obtained by a double-tandem, single-acting cylinder engine; that is to say, one having four single-acting cylinders operating on to two cranks.

THE ECONOMIC VALUE OF WATER-POWER

FROM "THE ELECTRICAL REVIEW" LONDON

In his presidential address at the Technical High School Fredericiana, in Karlsruhe, the Rector, Prof. Dr. Rehbock, the purchase of whose plans for the Murgthal Barrage by the Baden Government has brought the resources of this country for electrical water-power schemes prominently into the foreground, gave an interesting résumé of the economic value of water-power as compared with steam-generated power. After tracing the application of mechanical power to the use of mankind from its infancy, the Professor laid stress upon the fact that steam-driven, as compared with water-driven, power works present the advantage that they may be erected anywhere; thus costly transmission of power over long distances is avoided, while in many parts of the world, especially in low-lying parts, no water-power is available. Another important factor is that heat-driven works can always be utilized to their full capacity, while water-driven works, unless provided with sufficiently large storage reservoirs, have to reduce their output at certain times of scarcity of water supply.

The points in favor of water-driven works are that they are cleaner, do not vitiate the atmosphere, and are less dependent upon the ability or willingness of the staff (practically unaffected by strikes). They are perfectly independent of the difficulties connected with the supply of fuel, and, above all, they produce energy at a low cost.

The cost of the unit of energy is naturally the most telling factor in this comparison. Under the best possible conditions, i. e., when erected near coal deposits and with regular and continuous work, heat-driven power works cannot produce a kilowatt-hour under 0.25 ct. to 0.5 ct., equal to 0.38 ct. to 0.75 ct. at the switchboard. If the demand is subject to great variations, as, for instance, in light and railway supply stations, and when coal has to be obtained from a distance, that cost is often more than doubled. High-pressure water-power works are able to produce the power at one-half or one-third less, and even the low-pressure works, though more expensive, produce power at a much lower cost than it is possible for heat-driven works to do.

In any important power work it is a question of providing many millions—sometimes more than 100 millions—of such units per year, and this means an economic advantage of such great value that it will compensate the mountainous districts, which are rich in water, for any disadvantage they present as compared with the flat country districts.

The countries in which water-powers have been exploited in a large way, especially Switzerland, Austria and Upper Italy, have already found considerable profit by their venture. The rapid economic advance in this direction which has taken place in the last few years is, above all, due to the exploitation of the large water-powers of the Alpine rivers.

It is at present not possible to say with certainly how far the water-powers of any country will be able to cover the energy required. We can approximately estimate the power contained in the flowing rivers of some parts of the world's surface, where we know the area of the country, average height above sea level, evaporation and rainfall, and quantity of water flowing into the sea. What part of this theoretically available material can be put into practical use cannot be estimated exactly without devoting to it a study and labor

requiring much time, as the relation of the available supply to the production of energy varies very largely, and is dependent upon local conditions, supply of fuel, etc.

Theoretically, the energy of the flowing waters on the world's surface aggregates 8,000 million HP., or 143 HP. per square mile, and 5 HP. per inhabitant. In Germany these figures represent a total of 16 million HP., or 80 HP. per square mile, and about 1¼ HP. per inhabitant. The Grand Duchy of Baden possesses, quite apart from the power derivable from the Rhine, 1,000,000 HP., equal to 172 HP. per square mile, or ½ HP. per inhabitant. The power obtainable from the Baden shore of the Rhine would increase these figures to 2,600,000 HP.; 445 HP. per square mile, and 1¼ HP. per inhabitant. This means that Germany has only half of the world's average, while Baden has more than three times as much as far as area is concerned, although the density of the population reduces the figures to 1¼ HP. per inhabitant. In consequence of its mountains, heavy rainfall and the Alpine waters coming down the Rhine, the Grand Duchy of Baden is comparatively very rich in water-power.

Although no reliable estimate can be made of the world's power supply derivable from water-power, it is certain that there exists more than sufficient to supply all needs. Even taking the utilizable quantity at one-sixteenth of the total, an estimate which is really much too low, there will be 500,000,000 HP., or 9 HP. per square mile, which is ten times as much as the equivalent of the 1,000 million tons of coal, the demand on the coal resources in 1907. This is a most satisfactory circumstance, as the coal deposits of many civilized countries may be said only to be sufficient for the lifetime of a few generations, while the large deposits in China will only last for another few centuries if the demand keeps on increasing at its present rate.

While thus the world's supply is assured, the conditions in the different countries are very different. The apparently available supply of 2 to 2.5 million HP. in Germany is not equal even to the present demand. Amongst the German States, Baden takes the first place with about eight times of available power, while it is only second to Switzerland as regards all European States, and with the development of Lake Constance it could be made to take the first place in Europe amongst the countries possessing water-power.

At a low estimate, the cost would be 0.5 ct. per HP. per hour in unregulated high-pressure works, and in the case of exploiting the Rhine, where the installation is costly, but, on the other hand, the supply fluctuates very little. In high-pressure works regulated by storage reservoirs the cost would be 0.25 ct. per HP.-hour; those works may be estimated to cover 25% of the total. The total water-power available in Baden, at a rough but low estimate, represents an annual profit of $3,000,000 on a capital of $75,000,000. This represents a saving of two million tons of coal, or of $7,500,000, and each 25 cts. rise per ton of coal means a further saving of $500,000.

According to Mr. H. M. Wilson, in a recent issue of "Power," there is now a total of 4,500,000 HP. in the United States developed from water sources, and the investigations by the Government lead to the belief that this can be increased to 10,000,000. The water-resources branch of the Geological Survey is studying the water supplies of the country, with a view to ascertaining their availability for the production of power for the irrigation of arid lands, or the draining of swamp lands and for domestic uses. Its work will result in conserving the water supply by the construction of reservoirs for the storage of flood and the increase of dry-season discharges.

As yet, no estimate of even an approximate nature can be made of the water flowing perennially in our streams, or which may be impounded in storage reservoirs, and which may be made available for utilization in generating power. It is well known that but a small proportion of the available water-power in the streams is as yet so utilized. Unfortunately no statistics have been gathered of the present condition of the development of water-powers or their future possibilities. The following approximate data are presented in the light of the knowledge of the topography and hydrography of the United States, garnered from employees in various branches of that service.

In New England there is developed 1,000,000 HP., and there may be ultimately available for power purposes a total of 1,500,000 HP. In the Great Lake region the present development is 1,250,000 HP. with a possible development of 4,000,000. In the Piedmont region on the Atlantic and south Atlantic slopes, 1,250,000 HP. is now developed, with 3,000,000 possible of development. In the central Northwest 500,000 HP. has been developed, with a total of 1,000,000 possible. In the Rocky

mountain and Pacific regions there is now 1,500,000 HP. in operation, with 5,000,000 possible. In consequence of the water-resources branch there has been added in recent years nearly 1,000,000 HP. from water sources. All this power is of value in performing its share of conserving the fuel supply of the country.

COMBUSTION AND HEAT-BALANCING IN LOCOMOTIVES*

By LAWFORD H. FRY

Three losses with the heat usefully employed in the production of steam must account for all of the heat contained in the coal, and complete the heat balance.

(1) Loss of Heat in the Products of Combustion.—The products of combustion consist of certain dry gases, and in addition to these a considerable amount of water vapor from the water of combustion of hydrogen in the coal, and from the moisture in the coal and in the air. There is also a trace of sulphuric acid from the combustion of the sulphur. In the St. Louis tests the water of combustion with the sulphuric acid amounted to 0.40 lb. per pound of coal burned. The moisture in the coal was always in the neighborhood of 1%, and, therefore, the water vapor produced, per pound of coal burned, may be taken with sufficient accuracy as 0.41 lb., as fired. In addition to this vapor, the moisture in the air admitted for combustion must be taken into account. The percentage of moisture in the air can be determined from the wet and dry thermometer readings which were taken. The weight of the dry gaseous products of combustion per pound of coal burned is 0.54 lb. more than the weight of air supplied per pound of coal. The amount of heat carried off by the products of combustion depends on the weights of dry gas and water vapor produced per pound of coal burned; on the temperature at which they escape to the smoke-box; and on their specific heat.

(2) Loss of Heat by External Radiation.—This loss was not measured in the St. Louis tests. It seems, however, permissible to assume that the loss by external radiation is 5% of the heat utilized by the boiler in evaporation.

(3) Loss by Imperfect Combustion.—This falls under two heads:—

(i) Loss by production of carbon-monoxide.

(ii) Loss by escape of unburnt coal at chimney and ashpan.

(i) The first-mentioned loss can be calculated from the analysis of the flue gases. There is a general tendency for the loss by CO to increase as the rate of combustion is increased, but except in Series 100 there is no very serious loss on this score. In Series 100 one individual test shows a loss of 16.33% by CO. This is due to the rapidity with which the air supply falls off as the rate of combustion is increased. Evidently the difficulty of getting air to the fire limited the power of this boiler, and prevented the rate of combustion being pushed above 90 lbs. of coal per square foot per hour.

(ii) The loss of heat by the escape of unburnt coal is the most important loss in the heat balance when the boiler is working at full power. The coal escapes unburnt in three ways:—

As sparks; Into the ashpan; As unconsumed gas in the products of combustion, entailing a secondary loss by the sensible heat of the unconsumed gas in the smoke-box.

As the necessary observations were not taken, it is not possible in the present tests to determine the separate value of each of the four items of the loss by unburnt coal, but the total amount of heat lost can be determined by a method which is illustrated by the following example:—

In Test 8006 there is known	%
Heat of evaporation	47.20
Heat lost by external radiation	2.36
Heat lost in the production of CO	0.70
	50.26
This leaves as the loss to be divided between the products of combustion and unburnt coal	49.74
	100.00

*From a paper read before the Institution of Mechanical Engineers, dealing with experiments made on the locomotive testing plant of the Pennsylvania R. R. at the St. Louis Exhibition, and later at the Altoona (Pa.) shops.

The heat lost in this test in the products of combustion was 19.3% of the total heat of the coal actually burned. Now if, for example, 25% of the coal were to escape unburnt, the loss in the products of combustion would apply only on the remaining 75% actually burned, and would be 0.75 × 19.3, or 14.5% of the heat of all coal fired. Consequently, if P is the percentage of heat lost by coal escaping unburnt, the loss in the products of combustion is 19.3 [(100 — P)/ 100]% of the total coal fired, or calling this P_1 we have $P_1 = 19.3$ [(100 — P)/ 100], and $P_1 + P = 49.74$, whence, by simple algebra, it is found that P, the loss by unburnt coal, is 37.7%.

The general results of all the tests is that the efficiency of the absorption of the heat is practically independent of the rates of combustion and evaporation, so that under all conditions of working the heating surface absorbs about 81% of the heat produced by combustion. Approximately, the same figure is obtained for all four boilers, although they vary considerably as regards design and ratio of heating surface to grate area. The figures show that the efficiency of the boiler, as a whole, is mainly determined by the efficiency of the combustion, which falls rapidly as the rate of combustion is increased.

Although the smoke-box temperature at which the products of combustion escape increases as the rate of combustion increases, the percentage of the total heat carried away by these gases is reduced. This is due to the reduction of the weight of gas produced per pound of coal burned. When the rate of firing was increased from 30 lbs. to 130 lbs. per sq. ft. of grate, the weight of the products of combustion was reduced from about 18 lbs. to about 8.5 lbs. per lb. of coal fired. For complete combustion about 11 lbs. of air are required, so that when the boiler was forced it was not possible to get enough air through the fire to burn all of the coal fired. The figures obtained show that the locomotive of Series 100 is particularly choked for want of air. The author learnt with much interest, after writing the foregoing, that since the tests the Pennsylvania Railroad has increased the area of the air inlets in the ashpan of this locomotive, with the result that it steams much more freely and efficiently.

CALCULATING PORTLAND CEMENT CLINKER

The usual rule for calculating the clinker formed by burning a raw material is to add the percentages of silica, oxide of iron and alumina, lime and magnesia and to divide this sum into the percentage of each compound, multiplied by 100, for the percentage of that compound which will be present in the clinker. The results thus obtained for silica, for iron oxide and alumina will be too low and the lime much too high. This is because the ash of the fuel enters into the composition of the clinker, and also because the clinker contains constituents present in the raw materials not entirely volatilized in burning, viz., soda, potash, sulphur trioxide, etc., carbon dioxide and water.

To calculate the composition of the clinker from the analysis of the raw material is therefore impossible, and we must assume certain corrections. First of these is for the coal ash entering into the clinker. Experiments show that in the rotary kiln about one-half of the ash enters the clinker. West Virginia gas slack coal averages about 10% ash, composed of about 40% silica and about 20% each of iron oxide and alumina. If 90 lbs. of coal are required to burn a barrel of cement, about 15 lbs. (equivalent to 1.5 lbs. of ash) are required per 100 lbs. raw material burned. If half the ash enters the raw material, the silica is increased by ½ × 1.5 × 0.40 = 0.30%, and the iron and alumina each ½ × 1.5 × 0.20 = 0.15%.

Analyses of Lehigh Valley clinker, fresh from the kilns, show it to contain about 2% of potash, soda, sulphur compounds, carbon dioxide and water combined. Clinker from other localities will probably not vary widely from this.

Assuming the above corrections the rule for calculating clinker from the mix analysis is as follows:

Add the percentages of silica, oxide of iron, alumina, lime and magnesia. To the sum add 2.75. Call the result the "Clinker Total."

To find percentage of silica, add 0.30 to the percentage of silica in the raw material, multiply the sum by 100 and divide the "clinker total" as found above. The result will be the percentage of silica in the clinker.

To find percentage of iron oxide or alumina add 0.15 to the percentage of iron oxide or alumina in the material, multiply by 100 and divide by clinker total.

To find percentage of lime or magnesia, divide percentages of these by clinker total.—From "The Chemical Engineer."

ELECTRIC DRIVING OF ROLLING MILLS

AND THE CHOICE OF A PRIME MOVER

By WILLIAM T. DEAN

CONDENSED FROM THE "IRON TRADE REVIEW"

The recent successful development of internal combustion engines in large sizes suitable for use with blast furnace gas has directed the attention of steel works engineers and managers to the possibility of electrically driving all the machinery in such plants.

The first consideration in any particular case involving electric drive is—will it pay? Can more steel be turned out for a given cost, or the same steel for a lower cost than with a steam driven mill? The next question is—will the electric motor meet the severe requirements of steel mill practice such as continuous operation 24 hours per day and 30 days per month, will it withstand severe overloads even to the point of stalling, will the serious mechanical shocks incident to rolling, destroy bearings and deteriorate insulation to such an extent as to render the maintenance cost of such machines prohibitive? All the questions that arise affecting the adaptability of the motor for rolling mill operation have been asked and successfully answered in the past as applying to less important machinery. The solution of the problem from the electrical manufacturer's standpoint is only one of degree and therefore rests with the designer. That the many problems entering into the design of the successful mill motor can be solved is evidenced by the mills now being operated electrically and by those undertaken on so great a scale by the United States Steel Corporation.

The ability of a motor to operate continuously at a given load is only limited by its ability to radiate the heat in which the relatively small energy losses appear.

With reference to continuous operation no serious difficulties will be encountered. The electric motor has a great advantage over the steam engine in the matter of performance under overload. Speaking of the induction motor particularly, it may have an overload capacity as great as 2½ times its continuous output and the motor may be brought to a complete standstill by an unusual overload and the current flowing in the motor windings under these conditions may be precisely calculated before the motor is built, and provision made to limit the maximum current flowing to a predetermined value. What is of equally great importance, however, is the fact that the motor current may be automatically controlled so that excessive strains cannot occur.

The only uncommon problem in the design of large mill motors aside from that of mere size is that of mechanical proportions to withstand shock and ordinary wear. It is in this particular that the electrical manufacturer has been obliged to revolutionize all his previous ideas, profiting by the experience of the engine builder.

Many of the mechanical shocks occurring in rolling operations with steam engines are due to the reciprocating motion of the engine and not to the mill and gears. All such shocks disappear when a motor is used, for one of the motor's most valuable characteristics is its uniform turning moment.

Having outlined the manifest advantages of the motor for mill driving, the cost of operating a steam engine and an electric motor must be compared. Consider a mill requiring an engine or a motor of a given rated B. HP., and assume a non-reversing three-high mill operating practically continuously, conditions most favorable to the steam engine. If steam must be generated on the premises the engine-driven mill will be most economical since the motor must be charged with the cost of transformation from mechanical into electrical energy at the engine and generator, and the cost of transformation from electrical into mechanical energy at the motor as well as the transmission losses. Even the superior economies of large steam turbine generator units will not overcome such double transformation losses. Assume, however, that there is a distant source of power, natural gas, blast furnace gas, coke oven gas, cheap coal or water power, it will be conceded without argument that power may be transmitted more economically electrically than by any other means. It remains to show the

relative cost of transmission and the adaptability of the possible sources of power to rolling mill drive.

The internal combustion engine is not adapted to the direct driving of mills on account of its inability to sustain severe overloads and on account of its unstable action under widely varying loads. With gas power available the question narrows to the cost of the transmission of gas and the consumption of the same under boilers at the mill, as compared with the utilization of the gas at the source of supply to produce electrical power for transmission to motor driven mills.

In recent blast furnace practice, it has been found that approximately 123,000 cu. ft. of gas is produced per 24 hours per ton of pig iron. Two-thirds of this is available for power for the operation of blowing engines and other purposes, the remaining third being used to heat the air blast. A 500-ton furnace will produce therefore 41,000,000 cu. ft. of gas per 24 hours. Numerous tests have shown this gas to have a heat of combustion of 100 B. T. U. or more, per cu. ft. Assuming 90 B. T. U. per cu. ft. as a conservative figure the total heat available per 24 hours is 3,690,000 B. T. U. The heat equivalent of one horsepower is 2,545 B. T. U. Therefore, the theoretical power available from the gas is 1,450,000 HP.-hours, or 60,417 HP. Assuming the net efficiency of the gas engine at 22.5% which, if in error, is too high, the total available power from a 500-ton furnace is 13,600 HP.

On account of the lean quality of blast furnace gas, cylinder dimensions must be large and this has kept the size of single units down about 3,000 HP. and generators rated at 2,000 KW. are generally used. Such generators have an efficiency of about 95%, making the total electrical energy available per 500-ton furnace 9,360 KW. Of this power about 600 KW. is required to operate gas washing machinery, to pump jacket water, provide exciting current for alternating current generators and minor purposes, leaving a net available power of 9,000 KW.

As 1 KW. = 1.34 HP., 60,417 HP. = 45,000 KW., and 9,000/45,000 = 0.2, or the net efficiency of the entire plant will be 20%.

In a large power plant using steam turbine-driven generators and every known method of obtaining high efficiency, it has been found that 27,000 B. T. U. in the coal produce one kilowatt at the switchboard. This is under regular commercial conditions and includes all losses such as banking fires, operation of boiler feed pumps, circulating pumps, air pumps, coal and ash handling machinery, etc., and the plant in question is subject to heavy day loads and light night loads. Careful tests at this plant indicate that if the plant could be operated with a constant 24-hour load, such as obtains in steel mill practice, the economy would be 21,000 B. T. U. per kilowatt at the switchboard. In a similar plant, gas fired, but subject to a steady 24-hour load, a still higher economy could no doubt be secured by the use of furnaces, especially designed to burn the gas. Assuming, however, a fuel economy from gas of 21,000 B. T. U. per kilowatt, we have:

$$\frac{153{,}750{,}000 \text{ total B. T. U.}}{21{,}000 \text{ B. T. U. per kilowatt}} = 7{,}325 \text{ KW.}$$

or with the highest type of plant burning the gas to produce steam and using turbo-generators of large size the power available from a 500-ton blast furnace is 7,325 KW.

As before the theoretical power available is 45,000 KW., giving a net efficiency of 16.3%, or approximately four-fifths the efficiency of the gas engine plant. It should be noted that the higher output of the gas engine plant only applies to cases where blast furnace gas is available, since in producer gas plants the engine must be charged with the heat losses in the gas producer; moreover, the quality of coal for a gas producer must be much higher than is used in the steam plant, on the economy of which the above calculations are based.

The relative reliability of the gas engine and steam turbine plants must be given serious consideration. A steam turbine plant may be operated at its maximum rating indefinitely with almost absolute freedom from shut-downs or necessity of repairs. The gas engine, on the other hand, has not yet reached a perfection of development where it may be depended upon to operate 24 hours consecutively.

A complete turbine plant of large size, including the best machinery, boilers, auxiliaries, etc., and the highest type of station construction can be built for a least 60% of the cost of a blast furnace gas engine plan of the same capacity with its auxiliaries. Assuming as arbitrary figures that a steam turbine plant can be built for $60 per KW., and that a gas engine plant can be built for $100 per KW., and that a plant of 40,000 KW. average capacity is required, the investment in the turbine plant will be $2,400,000. The gas engine plant, however, will require at least 25% excess in capacity in order to maintain the average output given above and many engineers think that in the present stage of the art, 50% excess capacity should be installed. The investment in

the gas engine plant will therefore be $5,000,000, or 108.2% in excess of the investment in the steam turbine plant. The interest on $2,600,000 (the difference in investment) at 5% is $130,000 per year, or sufficient to buy 86,750 tons of coal. If this coal were burned under boilers in addition to the gas obtained from the blast furnaces, it would generate 86,750,000 KW.-hrs., or 1,156 KW. 24 hours per day, 26 days per month, throughout the year. This figure makes a very respectable addition to the power given above, which may be legitimately expected to be generated by the steam turbine plant and leaves a relatively small margin of total power in favor of the gas engine plant.

From this showing, the plants depending entirely on gas engines must face very unfavorable conditions. They will have on their hands enormously expensive plants, requiring four or five times as much labor as the equivalent steam turbine plant with constant danger of delay, due to breakdowns and with maintenance expenses reaching large figures.

In addition to all inherent disadvantages of the gas engine plant previously noted, the fact must not be overlooked that in the space occupied by one 2,000-KW. gas engine generator, a steam turbine unit having a rating of 14,000 KW. can be installed with all its accessories, and that a gas washing plant used with the gas engines requires more space than a boiler plant for an equivalent turbine installation. In fact, a gas engine plant with its accessories, requires so much space, both in the engine room and out, that considerable difficulty must be experienced to properly operate all sections as a unit plant.

The writer believes that the steam turbine system, while not the highest in efficiency, will provide ample power for all rolling mill purposes. If such is the case, the greater reliability of the steam turbine system far outweighs the lower fuel economy, and the extra investment in a gas engine plant will only pay in case there is a profitable market for the excess power outside of the steel mill proper.

There is another source of electrical power for existing steel plants which is extensively used in Europe, the steam regenerator and low pressure turbo-generator receiving an intermittent steam supply from reversing mills or from non-reversing mills subject to wide variations in load or speed or both and delivering a constant supply of electrical energy.

A large reversing engine requires 60 lbs. of steam (or more) per horsepower. A steam turbine operating between 15 lbs. absolute pressure and 28 ins. vacuum requires 45 lbs. of steam per KW-hr. Thus, there is available 1.33 KW. in electrical energy for each horsepower on such engines, more than enough to operate a duplicate mill electrically. The gain by such an installation is all "velvet" and requires a relatively small outlay of capital.

In choosing a system of transmission and utilization of the electric drive the steel works engineer is at first inclined toward direct current, owing to his greater familiarity with that system and to its apparent simplicity. A direct current system has some advantages, such as the extension of an existing plant to care for the heavier requirements of rolling mill drive. However, unless the centers of distribution of the power are very close to the generators, the transmission line will be so expensive as to be prohibitive. If an alternating current system is selected the cost of the transmission line may be reduced to a relatively small proportion of the plant equipment.

Alternating current motors are now offered, which successfully perform all the functions of direct current motors and have many superiorities, such as absence of commutator and ability to handle extreme overloads. These motors are built in all sizes for the operation of roller tables as well as for the operation of the main rolls, hence there is no longer an excuse for the direct current system where large powers are used.

The choice of frequency is limited to 25 or 60 cycles. The lower frequency is preferable, owing to the lower motor speeds obtainable with reasonable cost.

The question of suitable speed for a motor driving a rolling mill should be solved by the mill engineer rather than the motor manufacturer. The former should, however, bear in mind the limitations of speed within which the latter must work. Probably the lowest speed for direct connection to rolls which would be considered would be 50 r. p. m., for 25-cycle motors.

Whenever the speed of the rolls exceeds 55 r. p. m. it is preferable and cheaper to direct connect the motor than to employ a gear reduction. This refers to mills requiring motors of 3,000 HP. and larger for a single roll stand, and to many cases where smaller motors would be employed. Where it is necessary to drive more than one roll stand from a single motor, thus entailing gearing which would in any case be charged against the mill, a higher speed motor should be used, but in no case should the

gear ratio be greater than 3:1. For motors of 2,500 HP. or larger, a lower gear ratio should be selected.

For a close group of small mills, each of which in succession does a portion of the total work of reducing a bloom to a commercial shape, the most economical drive is by a single motor. This is due to the higher efficiency of a single motor of large size over several small motors and to the fact that such a motor may be operated at more nearly its full load continuously. The first cost of such a plan will be appreciably lower when a single large motor is installed.

The method of driving a group of small mills from a single motor must be very carefully considered in each case. If bevel gears are used the driving shaft must operate at a relatively low speed in order to avoid the use of too high a gear ratio between the shaft and rolls. This means a low speed and consequently an expensive motor. If the conditions will allow the use of a rope drive the motor may have a fairly high speed and the total friction loss may be reduced. It is probable that the maintenance cost of a rope drive for a group of small mills will be lower than for the equivalent bevel gear drive. Any flexible connection, such as a rope drive between the mills and the motor, will be favorable to the operation of the latter. In general it may be said that the higher the motor speed adopted the better will be the efficiency and power factor. This is shown by the curves giving approximate value of power factor and efficiency for a 5,000-HP. motor designed for various synchronous speeds.

THE UTILIZATION OF FUELS*

By PROF. VIVIAN B. LEWES

The fuels we have at our disposal for the commercial generation of heat may be tabulated as follows together with their calorific values:

AVERAGE THERMAL VALUE OF FUELS.

Solid Fuel.	British Thermal Units per lb.
Coal:	
Newcastle and Welsh	15,200
Lancashire and Derbyshire	14,600
Anthracite	15,600
Coke	14,300
Peat:	
20 per cent. water	7,200
5 per cent. water	9,900
Wood (average)	8,600
Charcoal	14,600
Liquid Fuel.	
Petroleum (fuel):	
American and Russian	19,500
Caucasus, Borneo, Burmah	18,700
Blast-furnace and tar oils	16,000
Alcohol, absolute	12,931
Alcohol, 10 per cent. water	11,520
Alcohol, methylated	11,160
Gaseous Fuel.	
Natural gas	21,615
Coal gas (London 16 c. p.)	19,220
Water gas (blue)	7,980
Mond gas	2,525
Dowson gas	2,353
Suction plant gas	2,160
Air-coke gas	972
Blast-furnace gas	951

It is not enough to know the calorific value of a fuel—one most know the work it has to do and be able to fit the fuel to that work before true economy and success can be attained, and it is for this reason some fuels so poor in calories as to have been hardly considered until lately, have achieved the greatest success, while others of many times the heating value have been more successful in fouling the atmosphere than in doing the work needed.

The calorific value of fuel, however, is chiefly of use in giving a comparison between the fuels themselves, and in its utilization we must take into consideration the work which that fuel has to do, and how far it is fitted to that work. If we were restricted to the use of coal and required a high local intensity for the fusion of a metal in a furnace, anthracite, which burns with hardly any flame and gives great local heat during the combustion of the high percentage of carbon it contains, would be manifestly the best fuel to employ, while if one required a considerable volume of flame to generate heat in the combustion chamber and tubes of a marine boiler, we should find that the more bituminous coals, although giv-

*From a lecture delivered before the Society of Arts, London.

ing plenty of flame, would at the same time give too much smoke, and natural fitting of the fuel to the work would eventually lead us to adopt Welsh steam coal, which would give us a maximum of heat and flame in the furnace and tubes with a minimum of smoke from the funnel; that is, we should by a practical process of elimination arrive at the point at which we could get the highest efficiency from the fuel, but when we came to make up the balance sheet of thermal units which we had first of all utilized in the generation of steam and then converted into power by means of the marine engine, we should find that it would only be a small proportion of the energy latent in the coal which had been translated into work, so that the real question for solution would be more dependent upon the suitability of the fuel, that is, the ease with which it could be used and the amount of power that could be got from it, rather than the amount of power that was originally in it.

During the first half of the last century it was solid fuel only that was employed for the generation of heat and power, but the last half of the century has seen the advent of liquid and gaseous fuels, which under certain conditions proved themselves of the greatest value, and certain processes are now largely dependent upon their use, this being due to the ease of application which has meant economy in labor and greater facility for converting the heat into work. As an example of the ease of application making a fuel of poor calorific value more effective in use than coal of high quality, one may instance such manufactures as those of glass, where in the heating by solid fuel the necessary temperature had to be imparted to the mass of raw material through the walls of a thick fire-clay retort, the difficulty of application here being dependent upon the fact that the crucible had to be heated to a very high temperature to get the necessary fusing point of the glass mixture, and that maintaining this for a considerable period meant a big expenditure in fuel and great wear and tear to the furnace and containing vessel. It was clear that if the fuel could be gasified, and the clean flame made to play directly on to the surface of the mixture to be fused, instead of having to impart the heat through the walls of the containing vessel, an enormous economy would be obtained, and this is now done by the utilization of producer gas and regeneration in the continuous tank process.

In the same way liquid fuel, as soon as methods could be found for its proper combustion, presented such wonderful economies and advantages for marine work that, in spite of its being dearer than coal, it at once found a place in both the Service and the Mercantile Marine. The possibility of being able to store it below the level of the boiler in the ballast tanks instead of having as in coal bunkers, to have the storage above that level, at once gave increased space in the important part of the vessel, and, what was of much greater importance in the service, the being able to carry a larger supply of latent energy in the same space as the coal occupied increased the radius of action of the vessel.

Other important economies, such as the amount of labor required and ease with which fuel could be taken on board, not only when alongside but from barges and other vessels when afloat, all tended to economy in use, and the only reason for its not having been universally adopted for service purposes is that the world's supply of fuel oil would not be sufficient to meet the demand of the Navy as well as the other demands for it, while being largely dependent for our supply upon foreign countries might prove disastrous in time of war, with the result that it is only employed as an auxiliary to, instead of entirely replacing, coal.

The total oil output of the world may be taken as being about 20,000,000 tons per annum as against 800,000,000 of coal, and of this oil at best only one-third is available for fuel purposes. The crude oil as it comes from the well would be absolutely unfitted for use, as in most cases it gives off inflammable vapors at air temperatures, and these mingling with the air form highly explosive mixtures. The temperature at which such inflammable vapor is evolved is called the "flash point" of the oil, and for use in the British Navy no oil with a flash point below 200° F. is allowed on board, although in the German Navy and the Mercantile Marine the limit is fixed at 150°. This necessary limitation means that the crude oil as it comes from the well has first to undergo a process of distillation, the more volatile portions yielding petroleum spirit or petrol, employed in motor cars, etc., while higher fractions flashing above 73° F. form the lamp oil, used for illuminating purposes, and with most crude oils it is only the residue, which from American oil is called "residuum" and from Russian oil "Ostatki," that fuel oil supplies can be drawn.

Not only does the use of liquid fuel for marine purposes present great economies in labor

and storage, but weight for weight it has, when properly used, over 40% greater evaporative power.

By far the largest percentages of coal are used in factories and works where it is employed for the production of heat and power, and for these purposes it has now been realized that the gasification of the coal before use leads to such enormous economies that this procedure is almost universal in Germany, and has been adopted in many of the more up-to-date works in this Kingdom, and the subject of power gas production is one of the most interesting of the day.

The idea of making a poor fuel gas by passing air through a column of incandescent carbon in an enclosed generator probably dates back to Bischof's experiments in 1839, but was elaborated in 1857 by Siemens, and in combination with his system of regeneration it achieved a wonderful success and revolutionized many manufacturing processes.

In the earlier form of generator the air was sucked by a chimney draught through the fuel bed.

The trouble and limitations caused by sucking the air blast through soon gave rise to the idea of forcing air through by means of a blower, but when this was done it was found that the temperature of the fuel in the generator became so intense that troubles with clinkering and fusing of the furnace bars soon resulted, which, however, could be got over by injecting steam with the air into the fuel bed, and this could be conveniently done by using a steam injector in place of a blower. It was then found that the presence of the steam not only kept down the temperature in the generator to a point which could be regulated to a nicety by the amount of steam used, but also brought the calorific value of the gas formed up from 72 B.T.U. per cu. ft. to just double that amount, this being due to the decomposition of the steam by the incandescent carbon giving a large proportion of hydrogen to the gas. This so-called semi-water gas or Dowson gas has an average composition of:

Dowson producer gas.	%
Carbon monoxide	25.07
Carbon dioxide	6.37
Hydrogen	18.73
Methane	0.64
Nitrogen	48.98

and this gas, being found not only excellent for the heating of furnaces but also well adapted for use in the internal combustion motor, was capable of providing all the heat and power required in a works.

A modification of this method was employed by Dr. Ludwig Mond, and has proved itself very successful for the production of power in large works. In this process the temperature of the fuel in the generator is kept down by the use of large volumes of steam, no less than 2½ tons of steam and 3 tons of air being used in the gasification of every ton of slack, and the great advantage of this method of working is that the nitrogen present in slack coal to the extent of about 1% becomes converted into ammonia, which can be extracted from the gas as ammonium sulphate by washing it in its passage through the scrubbers with dilute sulphuric acid, the sulphate of ammonia so formed being one of the most important manures for agricultural purposes, and for which there is an almost unlimited demand, and the price obtained for the by-product makes the gas obtained in this way an extremely cheap form of power, but only becomes economical when done on a big scale in works using about 4,000 HP.

It must be borne in mind that the gas made from coal by destructive distillation is, after all, next to natural gas, the most valuable of the gaseous fuels, as it contains from three to four times the heating value of the semi-water gas, and the only thing which militates against its use is its cost. If only coal gas could be supplied at 24 to 36 cents per thousand, it would be one of the most valuable fuels for all purposes.

Water gas, which was first discovered at the close of the eighteenth century, and was made a commercial success only within the last twenty years, is a mixture of nearly equal proportions of hydrogen and carbon monoxide, produced by the passage of steam through incandescent carbon, and when made by such improved processes as the Dellwik has now proved of enormous value for the welding of big tubes and for other purposes of that kind to which the application of solid fuel would offer many difficulties.

The conversion of a solid fuel, like coal, into gaseous fuel, entails a loss of at least 20% of the heat units present in the coal. For instance, taking a ton of slack, with an average heating value of 15,000 B.T.U., one could make from it 11,900 lbs. of producer gas, which would contain 25,704,000 B.T.U., but the coal itself would have contained 33,600,000, while if we had taken coke and had converted it into 2,600 lbs. of water gas, this would have contained 20,748,000 B.T.U.,

whereas the coke, with its calorific value of 14,226 B.T.U. per lb., would have been about 20% more.

When, however, we come to burn the coal by direct firing we find that there are several factors which reduce the amount of heat that can be utilized to a small fraction of the original.

On first stoking the furnace fire dense smoke is at once seen to issue from the chimney, owing to the fact that the heat of the fire is distilling off gas and tar vapor at such a rate that a considerable proportion escapes complete combustion, the same action of distilling out the gas and vapor rendering latent a certain amount of heat, while the escape of products of incomplete combustion and even unburnt vapors and hydrocarbon gases still still further lower the amount of energy that is converted into sensible heat. Then, again, double or treble the quantity of air indicated by theory has to be employed in order to get anything like complete combustion, and as this air consists of approximately only one-fifth oxygen, and all the residual nitrogen as well as the products of combustion are heated to a very high temperature and are carried away up the chimney, this also means a heavy heat loss, and the final result is that it has been estimated that in a very large proportion of furnaces only 10% or even less of the heat value of the fuel is actually used.

When, however, the fuel has been first gasified, the gaseous fuel requires only a comparatively small proportion of air to complete its combustion, and owing to its mobility in the gaseous state this air can be so completely mingled with the combustible gases as to insure complete combustion taking place with very little more than the theoretical quantity of air, the loss of heat by distillation is avoided, combustion is complete, and the products of combustion being entirely gaseous and free from soot, the heat in them, instead of being carried away by the chimney, can be received in regenerative devices and returned to the furnace. The result is that the total amount of heat utilized will be four or five times as great as when coal was employed, and this not only makes up for the loss of the 20% due to gasification, but leaves a large margin of economy and does away with the black pall of smoke, which, issuing from the factory shaft where solid fuel is used, forms a dense smoke cloud over our manufacturing centers.

It must also be remembered that with direct firing each furnace has to be separately fed, and that although mechanical stokers and other labor-saving devices will reduce both smoke and labor, yet nothing can compete in a large works with the convenience and economy of gasifying the whole of the fuel used in a generator of a modified Mond type, recovering the nitrogen of the slack in the form of ammonium sulphate, and piping the gas through the area of the works for combustion in the various furnaces, while the gas serves not only for heating, but for power purposes, when the economy in use is even greater than for furnace firing.

In enumerating the advantages and economies of gaseous fuel it is usual to lay great stress upon the fact that slack, smalls and smudge are used, and that these, being of no use as domestic fuel, could be obtained at a very low price. A very curious phase of the fuel question, however, has arisen, in that all the improvements in combustion devices having been designed with a view to utilizing this cheap fuel, the result has been that in manufacturing districts the demand for it is now greater than that for sizable coal, so that it has risen in price to a point at which the vast economies attributed to it in the past have practically disappeared.

CALCULATIONS FOR CHOKING COILS

FROM "THE PRACTICAL ENGINEER," LONDON

It frequently happens in practice that some form of electrical apparatus has to be connected to the supply mains having a higher voltage than that for which the apparatus is designed, and in such cases it becomes necessary to reduce the voltage so that the current flowing through the apparatus does not reach an abnormal value. As an example, an arc lamp requiring only 50 volts may have to be supplied with current from mains working at 100 volts or over. The best way out of the difficulty is to connect two or more lamps in series; but this is not always possible, and even if it is possible it may not be desirable.

In the case of a direct-current supply, the problem of reducing the voltage at the lamp terminals is very easily solved, for it simply remains to design an ohmic resistance which, when the proper current is flowing through it, gives the desired drop. This is extremely simple, but, at the same time, gives rise to considerable waste of power, as can readily be seen, the same number of watts being wasted in the resistance as are being expended on the lamp, and consequently the consumer pays just as much for reducing the pressure as is paid for the light. Unfortunately, with direct current this is unavoidable, but where an alternating current is used this loss can be very much reduced if a choking coil is used in place of the ohmic resistance. The design of a choking coil presents but little difficulty, and involves no great knowledge of alternating current. In the first place, it is necessary to observe that the voltage which must exist across the terminals of the choking coil to reduce the voltage at the lamp terminals is not given by 100—50, as previously shown for an ohmic resistance for use in a direct-current circuit. In the present case the E.M.F. due to the self-induction of the choking coil is very nearly 90° out of phase with the effective E.M.F. The various voltages which we have to deal with may be represented by a right-angled triangle. The base of this triangle represents the voltage across the terminals of the lamp, the perpendicular the volts across the choking coil, and the hypothenuse the voltage across the mains. Hence, if we know the voltage across the mains and the voltage required across the lamp, we can find the value of the choking-coil voltage, for it is the length of the perpendicular of the triangle. Using the same figures as before, we have voltage across choking coil terminals equals

$$\sqrt{100^2 - 50^2} = 87 \text{ volts.}$$

Having found the voltage which the choking coil must give across its terminals, let us examine the formula for giving the voltage of a choking coil. The formula is

$$E = \frac{4.44\ N\ n\ T}{10^8} \quad \ldots\ldots\ldots (1)$$

where N is the magnetic flux, n the periodicity of the supply, and T the number of turns. It will be seen from this that the only two quantities over which we have control in designing a choking coil are N and T, and that we can vary these in whatever way we like, provided their product remains constant. From the above formula—

$$N\ T = \frac{E \times 10^8}{4.44\ n} \quad \ldots\ldots\ldots (2)$$

At this stage it may be mentioned that in a choking coil of this type it is not advisable to have a closed magnetic circuit, as would be obtained, for example, by winding the wire on a laminated iron ring. If we do this the reluctance of the magnetic circuit would be very small, and we should have a big N, and a correspondingly large section of iron. It is usual with such choking coils to introduce an air gap in the iron circuit, and in the calculations to neglect the reluctance of the iron part of the circuit, and to assume that the whole of the reluctance is due to this air gap. Plates of 15 mils. thickness, and of the shape of a block letter "C," frequently constitute the core for choking coils of this type. In the present example we will fix the length of the air gap at 0.5 cm. The volume of iron to be used can best be found by deciding upon what loss is to be allowed in the core. The watts taken by the lamp are $10 \times 50 = 500$, and if we limit the core losses to 10% of this it will be a very fair value, and it will be noticed, neglecting the loss in the windings, a saving of 40% will result by employing a choking coil instead of the ohmic resistance. The formula for the iron losses in a transformer or choking coil is

$$W = V\ (K\ n\ B^{1.6} \times 10^{-7} + t^2\ n^2\ B^2 \times 10^{-16})$$

where V is the volume of the iron in cubic centimeters, n the periodicity, K a constant $=0.0024$, t the thickness of the iron plates in mils., and B the maximum flux density. As regards the last quantity, this is the virtual flux density multiplied by $\sqrt{2}$, or 1.414. In the same way we shall presently have to deal with the maximum current, which is 1.414 times the virtual current, or the current registered on the ammeter. If we take the virtual flux density as 5,000 per sq. cm., which is a suitable value for choking coils, then the maximum flux density will be $5{,}000 \times 1.414 = 7{,}000$. Assuming the periodicity of the circuit to be 80 cycles per second, we can then fill in the values of the above formula, and calculate the volume of the iron, which will be found to be 1,470 cu. cm.

In order to find the number of turns of wire to wind on the core, it will be convenient to assume that we have only to force the mag-

netic lines through the air gap. If we do this, then we may write

Ampere turns AT = L B/1.257

where L is the length of the air gap in centimeters. Putting the values in this formula, we have AT = 2,800.

Dividing this by the maximum current $\sqrt{2} \times 10$, we have

2,800/14.14 = 200 turns.

Multiplying this value by the flux in one square centimeter of the iron, we have 200 × 7,000 = 1,400,000; but if we put the values in formula (2) we can calculate what the actual product of the flux and turns should be:

$$\frac{87 \times 10^8}{4.44 \times 80} = 24{,}500{,}000.$$

It will be noticed that 87 is the virtual value of the volts, as registered by the voltmeter. Therefore, to find the area of the core, we must make 1,400,000 a virtual value—that is, divide it by $\sqrt{2}$, when we have area of core

$$= \frac{\frac{24{,}500{,}000}{1{,}400{,}000}}{\sqrt{2}} = 25 \text{ sq. cm.}$$

The total length of the core will obviously be the volume divided by the area,

or, 1,470/25 = 59 cm.,

measured from the two faces at the air gap. The core plates should be built up so as to give a square section 5 × 5 cm. It now simply remains to select a cotton-covered wire having a carrying capacity of 10 amperes on a basis of 1,000 amperes per sq. in., and to wind 200 turns on the limb opposite to the air gap. It may be found that a few more or a few less turns are required to get the correct voltage at the lamp terminals, and it is advisable to test the coil before the wire is cut. The laminations must be insulated from one another by insulating varnish or paint, or, better still, with thin paper fastened to the laminations with shellac varnish.

ELECTROMAGNETIC HARDNESS TESTER FOR IRON AND STEEL

By E. F. LAKE

SLIGHTLY CONDENSED FROM THE "AMERICAN MACHINIST"

As it is often desirable to know the exact degree of hardness of a piece of steel the principle of the magnetic balance has been brought into use and an instrument designed like that shown in Fig. 1 has given good results for certain classes of work.

Ferro-magnetic bodies are governed by the following two laws:

First—The magnetic capacity is directly proportional to the softness or molecular freedom.

Second—The resistance to a feeble external magnetic force is directly as the hardness or molecular rigidity.

These laws hold good for every variety of iron and steel and the magnetic balance shows that annealing not only produces softness in iron, and consequently molecular freedom, but it entirely frees it from all strains previously introduced by drawing or hammering.

Thus a bar of steel drawn and hammered may have a fibrous structure, and this would give a greater mechanical strength in one direction than in another, but if thoroughly annealed after heating to its highest recalescent point even traces of its former strains are removed and it becomes homogeneous in all directions by the molecular cohesive force equalizing itself in all directions from the common center. If, however, any distinct separations of the molecules have taken place, they will show in the form of microscopic crack, or in cracks large enough to be seen with the naked eye, and these will retard the equalization of the cohesive force.

The carbon contents of all steels are relatively proportional to their hardness, whether the metal be annealed, hardened or tempered; therefore, by using a hardness-testing instrument that will give accurately the degree of hardness, the carbon contents of the metal can be judged.

In calculating the carbon contents by this method different standards will have to be

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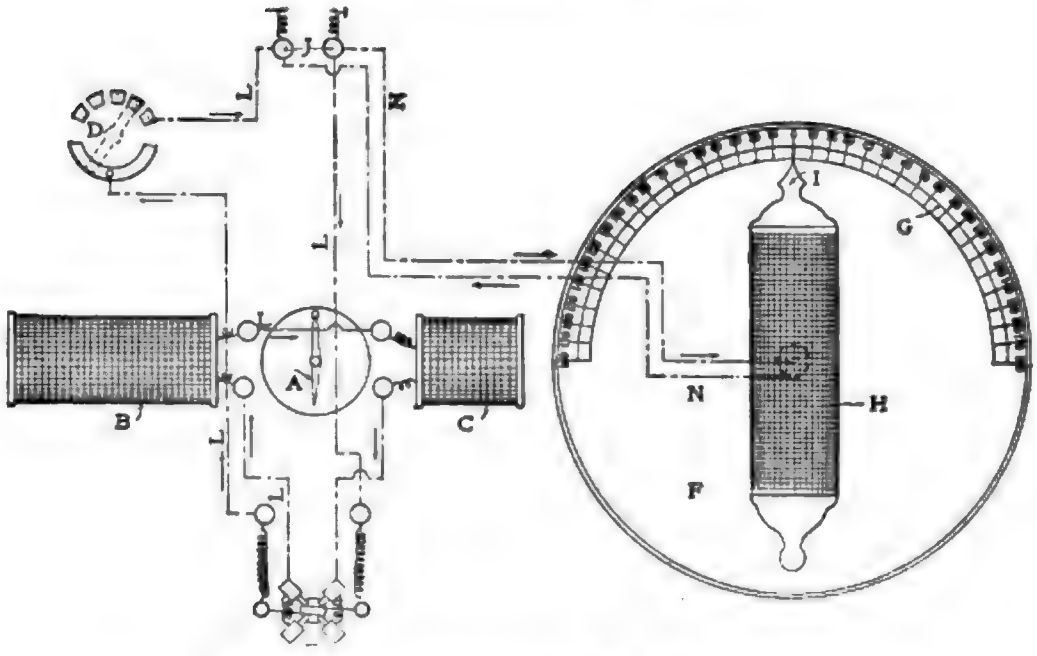

FIG. 1. DETAILS OF INSTRUMENT FOR TESTING HARDNESS.

used for different grades of steel, as some of the materials used in the ordinary and alloyed steels alter the degree of hardness given the metal by the carbon, but if a set of standards are established for the different grades of steel, then the percentage of carbon can be ascertained. Practical tests have shown that the carbon contents can be estimated within about 0.025%.

Hardness is only a relative term, yet to the practical mechanic working in steel it has a definite meaning, and it is one of the principal properties of this metal. If a set of standards have been established the degree of hardness will also indicate the tensile strength and other properties which a given grade of steel should have.

As the best grades of steel may fail if they are not properly heat-treated it is not only necessary to know the chemical composition and the physical properties of the metal, but also that the right degree of hardness has been obtained, as the highest efficiency of a given piece of steel is in all cases at a certain degree of hardness, whether that efficiency refers to strength, elasticity, cutting or any other qualities.

Thus accurately obtaining the degree of hardness is very important for many classes of work and the instrument described in this article will give these results on all paramagnetic metals which have not previously been magnetized. Metals which have been magnetized by numerous tests in this instrument or by some other means, will not give the readings which they should, owing to the greater resistance given the magnetic current sent through them by the instrument.

Tests can be made on pieces in the rough as well as finished work regardless of their shape. This makes a rail or projectile as easy to test as a finished razor blade, and materials can be tested before any work has been done on them, as well as getting the degree of accuracy with which the finished work has been heat-treated.

Table I. gives the magnetic capacity of cast iron and steel with different percentages of carbon from readings on the instrument. It also shows the tensile strengths which these metals should have.

On preparing the instrument for use the plate on which the apparatus is mounted must be perfectly horizontal. In order to obtain this position two spirit levels are affixed to the plate on either side of the magnetic needle, and four adjusting screws are used for feet on the under side of the plate. Two of these are shown in Fig. 2, and turning them to the right or left raises or lowers the plate.

The instrument must then be located so the magnetic needle A, Fig. 1, will point north and south when at the two zero points on the copper dial underneath it. The needle and dial are covered with a case with a glass top so as to eliminate the effects of the pressure and currents of the air. Oscillations of the needle are stopped by pressing on a push button which lowers the pivot until the needle strikes the dial.

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Methods of sampling.—In all 3 test specimens were taken from each of the 3 heats of steel. Heats were first cast in 3 ingots, and from each ingot 1 specimen was taken from the bottom, middle, and top. Each specimen was 1 inch square and 6 inches long. Before cold rolled the specimens were heated to a temperature of 1,600° F. and then rolled to a thickness of one-half inch. The specimens were then annealed at 1,600° F. and cooled in the furnace. A piece one inch in thickness was then sawed from each specimen and machined to a thickness of one-half inch.

The specimens were then heated and quenched in water from 1,600° F. The temperature of the quenching medium is not recommended. The specimens were then tempered at 1,200° F. and cooled in the furnace.

The specimens were then machined to the form shown in figure 1. The machining of a round was necessary in order to obtain a uniform section. The specimens were then heated to 1,600° F. and quenched in water. They were then tempered at 1,200° F. and cooled in the furnace.

Figure 1 shows the finished specimen. The machining of the specimens was done by the Bethlehem Steel Co. The machining of the specimens was done by the Bethlehem Steel Co. This machining was done by the Bethlehem Steel Co.

Before pulling the piece to be tested in the machine, the ends were filed down to fit the holes in the grips. The specimen is then placed in the machine and the autographic record traced on white paper fastened to a drum. The load is then put on the specimen by means of a lever. The load is increased gradually until the specimen breaks. The maximum load will occur when it breaks. The load is then released and the specimen removed.

Results of tests.—The results of the tests are shown in table 1. The results of the tests are shown in table 2. The results of the tests are shown in table 3. The results of the tests are shown in table 4. The results of the tests are shown in table 5. The results of the tests are shown in table 6. The results of the tests are shown in table 7. The results of the tests are shown in table 8. The results of the tests are shown in table 9. The results of the tests are shown in table 10.

FIG. 1.—SPECIMEN OF STEEL READY TO TEST.
(ORIG. 500).

FIG. 2. CARBURETTER SETTING WITH MANIFOLD CONNECTED.

Inlet valve still closed on this instrument.

be necessary to know the cubic contents of each of the cylinders. This is found by the formula $\pi r^2 l$, where r is the radius of the cylinder and l its length. Having found the cubic contents of one cylinder, the cubic contents for engines with two or more cylinders are found by multiplying by the number of cylinders.

After making a series of tests, it is found that the engine will develop its maximum power when the compression pressure is 100 lbs. per sq. in. Now, if the cubic contents of the cylinder when the piston is at the bottom of the stroke is known, the pressure when the piston is at any intermediate position in the stroke can be found by the following formula, in which p = pressure, v = volume, and n = 1.4:

$$v = p_1 v_1^n / p^n$$

Using this formula, the pressure can be found for any position of the piston in the stroke. Having the relation between volume and pressure, the work done during the compression stroke can be found. The work done during the expansion stroke is found in the same way. The difference between the two is the work done in compressing the charge.

The following table gives the results of tests made on a 4-cylinder engine, and is published by permission of the author of the paper:

Speed of Engine.	Brake Horse-power.	Indicated Horse-power.	Mechanical Efficiency.
1000	20.0	25.0	80
1200	24.0	30.0	80
1400	28.0	35.0	80
1600	32.0	40.0	80
1800	36.0	45.0	80
2000	40.0	50.0	80

The mechanical efficiency is the ratio shown by the brake-horse-power to the indicated horse-power. The indicated horse-power is found by the formula $\frac{PLAN}{33000}$, where P = mean effective pressure in lbs. per sq. in., L = length of stroke in feet, A = area of piston in sq. in., and N = number of explosions per minute. This is the theoretical horse-power developed by the engine, and is found by means of an instrument called an indicator. The brake-horse-power is found by means of a brake, which is a device for measuring the power developed by the engine. The brake consists of a pulley fixed to the engine shaft, and a rope or belt is wrapped round the pulley. One end of the rope is fastened to a spring balance, and the other end to a weight. The engine is then started, and the weight is gradually increased until the engine is on the point of stalling. The difference between the two readings of the spring balance is the force in lbs. which is required to stop the engine. The brake-horse-power is then found by the formula $\frac{2\pi RWN}{33000}$, where R = radius of brake wheel in feet, W = weight in lbs., and N = revolutions per minute.

The mechanical efficiency is low when compared with the electromagnetic instrument, typical figures for which are 90 per cent. and upwards. The mechanical efficiency of the internal-combustion engine is low because a large proportion of the energy is used in pumping fresh fuels into a new line, and in overcoming the friction of the moving parts. The mechanical efficiency of a steam engine is about 80 per cent., and that of a gas engine about 85 per cent. In the latter engine, therefore, a large proportion of the energy developed is used in overcoming the friction of the moving parts.

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1200	24.0	30.0	80
1400	28.0	35.0	80
1600	32.0	40.0	80
1800	36.0	45.0	80
2000	40.0	50.0	80

such as castings, as well as on finished work; that it gives positive readings or figures by which the hardest steels can be compared with others, as well as the softer steels, and that it can be operated without any special knowledge or skill. It will not, however, test non-ferrous metals, and is therefore limited to iron and steel.

The instrument is the invention of Prof. D. E. Hughes, and is sold in this country by Schuchardt & Schutte, 136 Liberty Street, New York.

DISPOSAL OF COAL TAR*

By CARROLL MILLER

CONDENSED FROM "THE PROGRESSIVE AGE"

The object of this article is to illustrate, in a condensed form, the value of tar as a by-product to both the gas and coke industries. The number of products which can be manufactured from coal tar, and the uses that may be made of them, being so numerous, the mentioning of a few of the most common will, I think, serve the purpose.

The demand for pitch and creosote, the largest products of distillation, seems to be increasing considerably; the former notably for briquette (patent fuel) making and the latter for preserving timber.

The growing demand for creosote may best be illustrated by quotations from the reports of Henry Grinnell, assistant forest inspector, who says, "The extraordinary increase in the use of the telephone and telegraph during the last few years (more than 2,650,000 a year), combined with the fast diminishing supply of timber used in pole-line construction, has led the telephone and telegraph companies to take great interest in experiments to find the best and most practical method for increasing the length of service of poles and crossarms."

According to "Engineering News" (January 23, 1908) 102,834,040 ties were purchased in 1906 by electric and steam railways. Of this number only about 12% were treated.

Trautwine ("Engineer's Pocket Book") gives the life of untreated ties at from five to nine years. He says that creosoted ties have remained sound after 22 years. Lunge ("Coal Tar and Ammonia") writes, "Numerous specimens of creosoted timber which have been found to be perfectly sound after being used as railway sleepers, fences, etc., for periods varying from 16 to 32 years."

The Department of Commerce and Labor states that 37,490,067,000 ft. (board measure) of lumber were handled by sawmills during 1906.

By glancing at the above figures a fair idea may be had of the prospective demand for creosote, as this substance has proved to be the best for timber preserving, although crude tar is also successfully used. I have dwelt on this subject at some length for, aside from its interest to coal-tar producers, it is of extreme importance to many other industries.

USES OF CRUDE TAR.

1. Paint.
2. Fuel.
3. Making and repairing roads.
4. Preserving timber.
5. Manufacture of roofing felt.
6. Manufacture of lamp black.
7. Gas making.

Distilling.—As the subject of distilling and refining tar is an extremely broad and lengthy one, I can here only touch on the general ties and will include but one purified product—naphthalene.

SIMPLE FRACTIONS OF DISTILLATION.

1. Ammoniacal liquor.
2. Light oil, including first runnings.
3. Middle oil.
4. Heavy oil.
5. Anthracene.
6. Pitch.

DISTILLATION PRODUCTS FOR SALE.

1. Ammoniacal liquor.
2. Light oil.
3. Creosote. (From 3, 4 and 5 in preceding list.)

*From a paper read before the New England Association of Gas Engineers.

4. Naphthalene. (From 3 and 4 in preceding list.)

5. Pitch.

UTILIZATION OF DISTILLATION PRODUCTS.

1. The ammoniacal liquor is disposed of in the usual way. It might be here noted that sulphate of ammonia is manufactured at many gas and coke oven plants in Europe, at some of which the sulphuric acid is made from spent oxide.

2. Light oil.—Uses: Illuminating, enriching gas, mixing with pitch to make varnishes, mixing with anthracene oil to prevent the absorption of illuminants when washing gas to remove naphthalene; usually, however, light oil is rectified to make benzol and naphtha and production of aniline.

3. Creosote.—Uses: Gas making, varnish making, to soften hard pitch, antiseptic, and preserving timber. When carbolic acid is extracted from middle oil, the residue is added to the creosote. Pyridine bases, which are used for denaturing alcohol, may be obtained from middle oil. Anthracene oil is used for extracting benzol from gas. Pure anthracene is obtained from the anthracene fraction.

4. Naphthalene.—Uses: Color making, making moth balls, burning for fuel and light.

5. Pitch.—Uses: Manufacture of briquettes (patent fuel), making varnish, roofing, roofing felt, making asphalt, road making and repairing, making lamp black, making coke, gas, etc.

An ordinary retort-house tar will yield on distillation about 220 gallons per 2,240-lb. ton.

YIELD OF TAR BY DISTILLATION.

Ammoniacal liquor	5 gals.
Light oil	6 gals.
Creosote	61 gals.
Pure naphthalene	90 lbs.
Pitch	1,350 lbs.

The proportion of these products may vary considerably, depending on the temperature at which the coal is carbonized, the character of the coal, etc. Coke-oven tar may give about the same amounts of products as the above, but usually the percentage of pitch is less. Coke-oven tar contains but a small amount of carbolic acid. In appearance, tar from vertical retorts is similar to that from coke ovens.

During 1907, nearly 20,000,000 tons (2,000 lbs.) of coke were produced in the Connellsville district, which would be equivalent to more than 25,000,000 tons of coal. If this coal were coked in by-product ovens, in addition to the coke, the following could be obtained:

Gas	75,000,000,000 cu. ft.
Tar	170,000,000 gals.
Ammonia	130,000,000 lbs.

Assuming 15 cts. per 1,000 cu. ft. for the gas, the equivalent in heat units of natural gas at 25 cts., 2½ cts. per gal. for tar and 6 cts. per lb. for ammonia, the income from these three items would amount to $23,300,000 or nearly $1 per ton of coal. In order to be on the safe side, I have used low figures for both the amounts and values of the by-products. If the tar were distilled and sulphate of ammonia manufactured, larger profits would be realized.

THE INFLUENCE OF AIR ON VACUUM IN SURFACE CONDENSERS*

By D. B. MORISON

If a condenser contained steam only and no air the vacuum would be governed by the mean temperature of the steam throughout the condenser, and an air pump would not be required. In practice, air exists in all steam condensers; its presence has the effect of retarding the condensation of the steam on the tube surface, and it has to be removed in a state of saturation with water vapor by an air pump.

When a condenser is at work and a stable condition has been established, the weight of air entering and leaving it in a given time is the same; but the ratio of air to steam in different parts is very variable. At the steam inlet the proportion of air to steam is, in a reasonably air-tight system, so small that its effect is negligible. As the fluid passes through

*Paper read before the Institution of Naval Architects, April 9, 1908.

the condenser and the steam condenses, the ratio of air to steam increases rapidly until at the air pump suction the air forms a very considerable proportion of the mixture. It is customary to refer to the fluid entering the condenser as "steam," and to the fluid leaving it as "air," but the two are of precisely the same nature, and differ only in the proportion of the constituents. It is true that what is termed air may not have exactly the composition of atmospheric air, but this is a point of little consequence in the present investigation. There is, as is well known, a definite temperature corresponding to any pressure of saturated steam. But there is also a definite—and lower—temperature corresponding to every proportion of air to steam in saturated air at every pressure.

It is important to note that, if water vapor is mixed with another gas or gases, the total pressure is the sum of the pressures of the several constituents, the pressure of each of which may be termed the partial pressure. The partial pressure of the water vapor is dependent only on the temperature; it is unaffected by the presence of the other gas or gases. If air saturated with water vapor is at a temperature of, say, 50° F., and if its total pressure is 2.95 lbs., then, as the partial pressure of water vapor at this temperature is 0.17 lb., the partial pressure of the air must be the difference between these figures, i.e., 2.95 — 0.17 = 2.78 lbs. per sq. in. The volume of air is, as is well known, dependent on its temperature and pressure, and can be readily calculated if these data are given.

The necessary capacity of the air pump depends on the point at which the air and steam are withdrawn, and a withdrawal far down on the vacuum curve would involve a relatively small air pump. But, as the transmission of heat through the metal of the condenser tubes from the steam to the water depends on the difference of temperature between these fluids, it is necessary, in order to obviate the necessity of unreasonably large condensers, to withdraw the air and vapor before the temperature of the mixture falls unduly. Hence it can be said that, for a given condensing surface and given steam and circulating water conditions, there is a limit in air ratio below which the mixture should not be carried; and this limit determines the minimum capacity of air pump necessary per lb. of steam in order to condense the required amount of steam per square foot of cooling surface at the required vacuum.

Even with an air pump capacity in proportion to the amount of air gaining access to a condenser, the efficiency of the condensing surface must be adversely affected by increased quantities of air passing through, because the opportunities for contact of the steam with the tube surface are thereby reduced. If the air pump capacity is not increased in proportion to an increase in air leakage, the lower rows of tubes automatically become ineffective for condensing purposes, and this so reduces the effective surface that a decrease in vacuum is required, and ensues, in order to re-establish the necessary equilibrium.

Consider, for example, a mixture of steam and air at a vacuum of 28.5 ins. at the bottom or exit end of a condenser through which the circulating water makes its first pass. If the relative proportion of air and vapor by weight are as 0.3 to 1, the temperature of the mixture is about 87°; but, if the air gaining access to the condenser is increased without a corresponding increase in the pump capacity, so that at the bottom of the condenser there are equal weights of air and vapor, the temperature is only 78°, and, if the weight of air is twice that of the vapor, the temperature is only 68°. With circulating water entering the condenser at, say, 60°, and having a mean temperature in the first pass through the lower rows of tubes of, say, 63°, 62° and 61°, respectively, in the three cases, the difference in temperature between the condensing water on the inside and the air and steam on the outside of these condenser tubes is 24°, 16° and 7°, respectively, and, as with unflooded tubes the transmission of heat is very nearly proportional to this difference of temperature, the great effect of the quantity of air on the capacity of the condenser will be apparent.

The above statement was, it will be noted, qualified by the expression "with unflooded tubes," because, with tubes heavily flooded by steam-water showering from the top, as is the case in a condenser of ordinary design, the air and steam cannot get access to the tubes, but make contact with this steam-water, which cannot be at a less temperature than the water within the lower tubes and will, in ordinary cases, as it comes from the upper and hotter portion of the condenser, be at a considerably higher temperature. If the steam-water flooding the lower tubes were at a temperature of 77°, then the difference between this and the saturated air would be 10° in the first case considered, and only 1° in the second, which is, therefore, barely practicable, the third case be-

ing, of course, impossible; so that in a condenser of ordinary proportions and design in which the condensed steam-water showers on to the lowermost tubes, the ratio of air to steam by weight at the air pump suction must be less than unity in order that a 28½-in. vacuum may be obtained with circulating water at 60°.

The weight of air entering the condenser with the steam depends on (a) the aggregate air leakage into the system at all parts subjected to pressure before atmospheric, and (b) the proportion of air contained by the feed-water when entering the boiler. The weight of air which can enter a boiler with the feed-water depends upon the amount of air in solution in the feed-water, together with the amount of air added by the feed pump. In marine practice the greatest amount of air results from the use of ordinary marine ram pumps, driven from the air pump crosshead by the main engines, and air is present in minimum amount when the feed pump is independently driven and float-controlled. The weight of air and other non-condensable gas in real or apparent solution in feed-water has been the subject of exhaustive investigation by the writer, and the results as affecting marine practice are, broadly, as follows:

Fresh water carried in tanks for use as auxiliary feed contains at atmospheric pressure from fully 2 to 3½ volumes of air per 100 volumes of water. If this water is introduced into the condenser, about 70% to 90% of its air is immediately given off. When the entire feed-water passes through an air pump, the air in the pump discharge amounts to from 1½ to 2%, depending on the conditions; but if this water is passed without disturbance into a feed tank and pumped therefrom by a float-control feed pump, it does not take up further air to any appreciable extent. Condensed water discharged by an air pump and repassed into the vacuum does not become supercharged by repeated circulation through the system, but settles down to a permanent charge of about 2%, which is slightly less than the average quantity contained in ordinary fresh water.

Broadly, it may be said that in no type of condenser can the condensing capacity due to its dimensions be maintained, unless the air pump is sufficient to render all the tube surface available for condensing steam; the air pump must, in fact, dominate the condenser under all conditions of normal air leakage, as the least insufficiency so reacts on the condenser as to ultimately put out of action a proportion of the entire condensing surface, with the result of a fall in vacuum.

A condensing plant may be said to be in an ideal condition when the only air in the system is that discharged into the boiler in solution with the feed-water, but in general practice there must of necessity be considerable air leakage associated with every plant, the amount being largely determined in any given case by the condition in which the plant can be maintained with average attention by those in charge.

THE AMERICAN PATENT SYSTEM*

In these days, when combinations in restraint of trade and most forms of monopoly are being dissolved and regulated, it is interesting to note there is one form of absolute monopoly that is not only tolerated but highly favored and protected by law. A United States Court in a recent decision said:

"Within his domain, the patentee is czar. The people must take the invention on the terms he dictates or let it alone for seventeen years."

Because the operation of the patent laws, like that of the laws of nature, is unobtrusive, comparatively few realize their importance, but they have been one of the most important factors in the development of our country from a few non-manufacturing colonies to the greatest of manufacturing countries. All of our great manufacturing companies own patents, and many of them built themselves on patents. The Bell Telephone Company, under the protection of its patents, had an absolute monopoly for seventeen years, and during that time so securely intrenched itself that it is now almost impossible for a competitor to displace it. Most of the large companies employ

*A review of an address delivered before the New England Society of Orange, N. J., April 4, 1908, by Edwin J. Prindle, of the New York Bar. The object of the address was to give the well-informed man a definite understanding of the importance, origin and working of the American Patent System.

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corps of inventors to keep their products ahead of the market.

One-tenth of the time of the United States Courts is devoted to patents. The patent law was expressly provided for in the Constitution, and patents are the subject of important treaties between the principal countries.

Before patents were granted, inventors could only endeavor to keep their inventions secret. Many a family and many an ancient guild counted a secret invention as its most precious possession. But in proportion to their value they tempted the cupidity of their competitors, and many a tragedy resulted from attempts to steal secret inventions. The secret of making Venetian glass was greatly prized and most jealously guarded. A Venetian named Paoli, who possessed the secret, left Venice and wandered northward practising his art. He was stabbed in Normandy with a dagger marked "Traitor"—a measure taken to protect the secret and a warning to others.

The inventor could only keep secret such inventions as could be practiced in secret, but a new article or machine, as soon as one was sold, could be copied by a competitor, who would be saved the often great expense of experiments to find how it should be designed to best serve its purpose. So there was no incentive to make inventions that could not be kept secret. The secret practice of the invention usually restricted its use to a single factory and limited the output of it. Then the invention often died with its discoverer and was never rediscovered. For these reasons both the public and the inventor profited by the system of the public giving the inventor an absolute monopoly of the invention for a limited period in consideration of a full disclosure of the invention and the right of the public to use the invention thereafter.

The monopoly granted by a patent is a peculiar one. It is negative in character. It grants the right to exclude all others from any making, using or selling of the invention. For this reason, the wording of the grant has a curious effect. The measure of the grant is termed the "claim," because it is a statement of what the inventor claims as his invention of all the machine or other subject matter which it is necessary to illustrate in the patent as an embodiment of his invention, for every invention, consciously or unconsciously, is an evolution of some earlier form. The law requires the claim to be drawn on behalf of the inventor, and the Patent Office sees that it is not more comprehensive than the real invention. The strange thing about a claim is that the more a claim says the less it means.

This was shown by examples of actual claims on inventions of bicycles, but the point was illustrated by likening a claim to a bill of sale for cattle on a Texas ranch. If it purported to give title to "all the short-horn Durham steers with one white foot and three black ones," it would convey perhaps only two or three steers, while if it said simply "all the livestock," it would convey all the steers of every kind, all cows, bulls, horses, pigs and sheep. So the less it says, the more a claim means.

The protection which a patent affords was illustrated by supposing a patent to have been granted for an invention, in bicycles, and a competitor to have tried appropriating the invention under a disguise in form. It was shown how a court would have applied the equitable "doctrine of equivalents" to enjoin the competitor and make him pay damages and profits if the patentee had not put it out of the court's power by too great limitations in his claim. Under the monopoly granted by a patent, an inventor may grant to a manufacturer the right to make the machines for him, but may reserve to himself the exclusive right to sell them. He may restrict the territory in which any one of his licensees can make, use or sell the patented invention, and he may restrict the number and price of the articles to be sold. The court, for instance, decided that it was lawful for the Edison Phonograph Company to require its licensee in New York not to sell phonographs below a certain price. It was recently held lawful for a patentee in rubber tires to license most of the rubber tire manufacturers in the United States under his patent, to require them not to sell below a certain price, and to require them to form an association to protect the interests of the patent—a combination which, but for the fact that it was under a patent, would have been a combination in restraint of trade under the famous "Sherman Act." The court, however, could not do less than sustain the validity of the arrangement under the liberal clause of the Constitution providing for the grant of patents.

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THE USE OF LIME IN BOILERS

CONDENSED FROM "THE MARINE ENGINEER AND NAVAL ARCHITECT"

Lime (CaO) is now recognized as the most efficient and trustworthy agent in preventing the inroads of the harmful lime salts found in sea water and some fresh shore waters the acids liberated from the various oils that find their way into the boiler, and the free gases carried in by the feed water or evolved in the boiler.

Soda (Na_2CO_3) is now seldom used for boiler work, except in very minute quantities, as it causes priming and injury to all joints not made of red lead—and even these are not immune if a soda solution is long in contact with them.

The use of lime in marine boilers must be considered under two heads:

First, as a preservative of the surfaces of a boiler with which in a solution it is in contact when standing full, partially full or working.

Secondly, as the neutralizer of the injurious acids and gases which may find their way into the boiler through the feed or may be generated in the boiler where working.

Lime as a Preservative.—When a boiler is pumped up from empty to full, lime is usually put in, in sufficient quantities to, at least, saturate the filling water. This is usually done by placing a quantity of milk of lime in the boiler and then pumping up to about 20 to 50 lbs. pressure to expel all air. This method is not to be recommended, as the circulation in a cold boiler is practically nil, and consequently when the boiler is partially full the mixing of the water and lime decreases, the inrushing water being the only stirring agent; thus intimate mixing of the water and the lime can hardly take place, and complete saturation of the water cannot be relied on as a certainty. This more especially applies to the top of the boiler, or upper drum, where saturation is most necessary, as all air and gases accumulate there. The better method is to have the lime regularly fed into the pumping-up water, as a much more intimate mixture of the lime and water takes place in the feed pipe and pump, and the whole mass of the water contained in the boiler is properly saturated.

The quantity of lime required to saturate water varies with the temperature of the water —the quantity decreasing as the temperature increases.

Three pounds of lime is required per ton of distilled water, when the temperature is 60° to 70° F., and 1½ lbs. when the temperature has risen to 212° F.

A boiler which is to stand for any length of time requires at least 3 lbs. of lime per ton of contained water—if distilled; more than this is not required, as the surplus settles to the bottom and may choke or injure the faces of the running-down valves.

Half an ounce of caustic soda (NaHO) per ton of water is used by some marine engineers, as it is believed to assist the water to absorb the lime and prevent any salts of lime forming a hard deposit on the shell or tubes. It certainly assists in rendering the water alkaline and can do no harm.

Boilers that are pumped up to working height and which will shortly be in action, do not require more than 1½ lbs. of lime per ton of water, and about a quarter of an ounce of caustic soda per ton of water if fancied.

These quantities of lime are simply preservative, and are not intended to kill the acids and gases introduced by the feed-water. These must be dealt with separately and in another manner.

Lime as a Preventive.—Lime as a preventive neutralizes the oil and fatty matter in the feed water and assists to render innoxious the oxygen and CO_2 held in suspension in the feed and make-up feed-water.

The dangerous oils and gases, which, when introduced into the boiler, do so much damage, are always found in the feed water in very minute particles; the oil, as a rule, in the ordinary feed water, coming from the condenser, the air and gases in the make-up feed. Air is very often introduced by the ordinary feed having a fall from the air pump discharge before it reaches the feed tank level.

The following rules are based on the assumption that one ton of coal evaporates 10 tons of water.

Boilers on auxiliary work only require about 3 ounces of lime per ton of coal burnt, to kill the oil in emulsion and neutralize as far as possible all free gases.

Boilers working on main and auxiliary machinery combined require 1½ to 2 ounces of lime per ton of coal burnt.

These quantities assume that the boilers are already charged to at least 1½ lbs. of lime per ton of contained water.

In either case reduce the lime to 1 ounce per ton of coal when the boiler gives a very sharp reaction to the litmus test.

Scum about one to two inches in the gage glass and blow out another one inch when the boilers have received 1½ to 2 lbs. of lime per ton of contained water through the feed. The scumming and blowing out should only be done when the boilers are working easily.

If carefully applied these rules should keep the boilers in good condition and effect considerable saving in fuel.

COMBINATION SYSTEM OF RECIPROCATING ENGINES AND STEAM TURBINES*

By C. A. PARSONS, D.Sc., M.A., and R. J. WALKER

It may be said that perhaps the most important field for the combined system of machinery, as applied to marine propulsion, is for those installations where the designed full speed of the vessel falls below the range suitable for an all-turbine arrangement, the reciprocating engine working in the region of pressure drop where the conditions are best suited for it, and the turbine utilizing that portion of the expansion diagram which the reciprocating engine is not able to utilize efficiently. It is generally well known that an all-turbine arrangement has not been advocated by us for ships where the designed speed falls below 15 or 16 knots, excepting in some special cases, such as yachts; and for vessels of moderate or slow speed the combination system of machinery appears to be eminently suitable.

In a good quadruple reciprocating engine, the steam is expanded down to the pressure of release, about 10 lbs. absolute, and gains in economy as the vacuum is increased up to about 25 ins. or 26 ins., whereas in a turbine it is possible to deal economically with very low-pressure steam, and to expand this low-pressure steam to a low absolute pressure corresponding to the highest vacuum obtainable in turbine practice.

In a combination system, the most suitable initial pressure for the turbine, or the dividing line between the reciprocating engine and the turbine, will greatly depend upon the conditions of service of the particular vessel taken. The reciprocating engine, or engines, can be designed to exhaust at a pressure of between 8 lbs. and 16 lbs. absolute, or even at a slightly higher pressure, if necessary, to meet the conditions required. From an estimate of the theoretical efficiency under the various conditions of pressure, it would appear, apart from any practical considerations, that there is nothing to choose between an initial pressure at the turbine of between 7 lbs. and 15 lbs. absolute, any pressure within this limit appearing to give the most economical result.

In the case of a vessel which runs on service continually at or about her designed full speed, an initial pressure of about 7 lbs. absolute at the turbine appears most suitable. In a vessel which does part of her running at the designed power, and part at a considerably reduced power, it is desirable to design the turbines so that the initial pressure would not fall below 7 lbs. absolute when running under the lower conditions of power.

With a quadruple-expansion reciprocating engine exhausting to the condenser direct, the maximum energy realizable from 200 lbs. pressure to 26 ins. vacuum, with point of release at 10 lbs. = 256 B. T. U. The energy which the reciprocating engine cannot efficiently utilize, but which can be used in a turbine = 73 B. T. U.

In a combination of a triple expansion engine exhausting to a turbine and thence to the condenser, the maximum energy realizable from 200 lbs. to 8 lbs., with point of release at 13 lbs. = 219 B. T. U. The energy available for the turbine from 7 lbs. to 28 ins.

*Condensed from a paper read before the Institution of Naval Architects, April 9, 1908.

vacuum, receiving wet steam from the reciprocating engine = 100 B. T. U. Total energy of combination = 319 B. T. U., which is 24½% greater than that of the reciprocating engine. (All pressures are absolute.)

It is estimated that a large portion of this additional energy can be expected to be realized by the combined system in the shape of increased power to drive the vessel, or, on the other hand, increased economy. These figures (theoretical) are computed on the basis of adiabatic expansion throughout.

Thus, it is estimated that a quadruple expansion engine using 95,000 lbs. of steam per hour at 200 lbs. pressure will develop 7,300 I.HP., working on a 26-in. vacuum. The same quantity of steam (using a 28-in. vacuum) will operate a 6,300-HP. triple expansion engine and a 2,000-HP. low-pressure turbine, or 8,300 I.HP. in all, an increase of 13.7%. A speed of 15.5 knots would be obtained with the former and one of 16.2 knots with the combined installation. The total steaming weight would be about 3% less with the combined installation.

METAL-FILAMENT AND CARBON-FILAMENT LAMPS

From the standpoint of current, candle-power, total watts and watts per candle, tantalum and tungsten lamps are less susceptible than carbon-filament lamps to changes in electrical pressures. The resistance of the metal filament increases, whereas that of the carbon usually decreases with rise in voltage.

At 85% of normal voltage a carbon lamp's resistance is 100.24% of that secured at normal voltage, that of the tantalum lamp is 95.5%, and of the tungsten lamp 93.5%. At 110% of normal voltage the per cent. of resistance to that at normal is 99.81 with a carbon lamp, 102.5 with a tantalum lamp, and 104 with a tungsten lamp.

On account of the different characteristics of the resistance of the carbon, tantalum and tungsten lamps the current is affected in such a way that at 85% of normal voltage it is reduced 15% with carbon lamps, 11% with tantalum lamps, and 9% with tungsten lamps, and at 110% of normal voltage the current of the carbon lamp is increased 10%, of the tantalum lamp 9%, and of the tungsten lamp 6%.

Since the resistance of tungsten and tantalum lamps operated at a voltage lower than normal, is less than that of carbon lamps, their current is higher respectively, and therefore their candle-power must be greater. The carbon lamp gives 41%, the tantalum 50%, and the tungsten 55% of its rated candle-power when operated at 85% of normal voltage, and 168%, 148%, and 141% candle-power, respectively, when run at 110% of correct voltage. This shows that the light delivered by metal-filament lamps is much less affected than that from cellulose-filament lamps by variation of voltage. It is a matter, however, which cannot be brought out too strongly. It can be shown that a drop of 5% from normal voltage causes a reduction of 25% in the illumination received from the carbon-filament lamp, 19.5% in that received from the tantalum lamp, and only 18% in that given by the tungsten lamp. A rise of the same percentage above normal causes an addition to candle-power of 31% with carbon lamps, 23% with tantalum lamps, and 19 per cent. with tungsten lamps.

The increase in total watts is less with metal than with carbon-filament lamps operated above voltage. Burning at an electrical pressure of 5% higher the energy consumed is increased 10% in a carbon lamp, 9% in a tantalum lamp, and 8% in a tungsten lamp.

The watts per candle do not vary as much with tantalum and tungsten lamps as with carbon when the voltage is changeable. Not only are the metal-filament illuminants far more efficient, but their percentage of change in watts per candle is much less when compared to carbon-filament lamps when run at a fluctuating voltage. Taking the specific consumption of the cellulose lamp as 3.1 watts per candle, the tantalum as 2.1 watts per candle, and the tungsten as 1.25 watts per candle at 100 volts, the respective specific consumptions would be 5.5 watts per candle, 3.8 watts per candle, and 1.76 watts per candle at 85 volts, and 2.23 watts per candle, 1.66 watts per candle, and 1.03 watts per candle at 110 volts.

When the electrical pressure is unsteady the performance of both the metal-filament lamps mentioned is certainly most gratifying. The nearer the results obtained at varying voltage come to that secured at normal, the more the troubles will be diminished of the generating stations and of the persons using electricity for lighting purposes. With every recent development of a new lamp a marked improvement has taken place in this respect.

PISTON SPEED AND STEAM ENGINE ECONOMY*

By PROF. R. L. WEIGHTON, M. A.

Some time ago a series of revolution trials were carried out on the experimental engines in the engineering laboratory at Armstrong College, Newcastle-on-Tyne. In general terms, the primary object was to ascertain by careful experiment the exact effect upon the steam consumption per brake horse-power of running engines of ordinary design and proportions—such, for instance, as are usual in marine practice—at varying speeds of revolution, ranging from the lowest up to the highest practicable, nothing being altered throughout the series except the resistance against which the engines were working. A second object was to discover, if possible, the maximum permissible speeds of steam and exhaust in such engines, with due regard to economy. This last with a view to the determination of the minimum sectional dimensions of the steam and exhaust ports, openings and passages, for adoption in proposed engines of this type, without entailing sacrifice of economy in working.

Two separate sets of trials were carried out, one with the engines arranged as quadruple, and the other as triple expansion, otherwise the conditions were as nearly as practicable identical for both sets, as follows:

Quadruples: Cylinders 7, 10½, 15½ and 23 ins. in diam.; 18-in. stroke.

Triples: Cylinders, 10½, 15½ and 23 ins. in diam.; 18-in. stroke.

Steam pressure in high-pressure chest, 138 lbs. per sq. in., absolute; vacuum in condenser (barometer 30 ins.), 24½ ins. of mercury. Jacket steam shut off and jacket drains open. Receivers continuously drained by hand into hotwell. Amount of lubrication of steam and of bearings, the same on both trials. Steam cut off in quadruples at 12½ ins., 10½ ins., 10½ ins. and 10½ ins., respectively; steam cut off in triples at 6 ins., 10½ ins. and 10½ ins., respectively. Engines in both cases linked up very slightly, and to exactly the same amount in every trial.

Conclusions.—The results of the trials may be summarized as follows:

(1) For every reciprocating steam engine, when change in power is brought about by change in piston speed, there is a certain limit of piston speed at which maximum power is attained, and beyond which the power will fall as the speed is increased. There is also a certain limit of piston speed with which is associated maximum economy of steam used per horse-power developed.

(2) For the engines and conditions of the trials, maximum economy in steam used per brake horse-power occurred for quadruples at a piston speed of 441 ft. per min., and for triples at a piston speed of 474 ft. per min., the corresponding mechanical efficiencies being for quadruples 0.856 and for triples 0.87.

(3) The maximum-economy piston speed depends on several factors, the exact influence of each of which remains to be ascertained, but to a very large extent it is determined by the mechanical efficiency of the engines. An increase in the value of mechanical efficiency will, other things being unaltered, not only raise the economy absolutely, but will advance the maximum-economy point on the scale of piston speed.

(4) Both maximum-power and maximum-economy piston speeds are for the brake power considerably lower than for the indicated power, and therefore if the indicated horse-power were alone considered, the piston speed of maximum economy would appear to be considerably higher than it is in reality.

*Paper read before the Northeast Coast Institution of Engineers and Shipbuilders, March 20, 1908.

TECHNICAL EDUCATION AND COLLEGE NOTES

TECHNICAL EDUCATION IN AMERICA*

By SIR WM. H. PREECE

It is difficult, if not impossible, to make any just comparison between the methods of technical education in America and those at home. The conditions are totally different. Climate, race, commerce, industry, fashion, wants and aims are different. We are a conservative, archaic nation, well provided with inertia, not wanting in wealth, accustomed to grandmotherly attentions, subject to the traditions of the past, and swayed by the precedents of our grandfathers. America is a congeries of numerous self-governing States, intensely ambitious, enjoying a champagne-like climate, formed of a mixture of all the Celtic, Teutonic and Latin races of Europe, inspired by a rapid and excessive flood of the wealth of the soil and the demands of a phenomenal inroad of aliens; abounding with advancing commerce and growing industry, and suffering from a great inroad of wealth and an immature system of finance. The American boy possesses the energy and smartness of a new race. The European boy is mentally two years behind him. His precocity is assisted by his keenness and his vivacity. He works with an object and a determination to succeed. He throws the same determination into his studies that he applies to his games. He is irresponsible and sometimes a terror. The absolute unfitness of these characteristics to the British boy must be self-evident, but they will account for the differences in the curricula, and the paper set for examination provided for these boys when they become students in colleges and universities. Teachers, like poets, are born, not made. The teachers differ but little from those in Europe, but they are excited to great energy by their natural enthusiasm, by climatic influences and by the reflected encouragement of their receptive pupils. Indeed, many are imported from France, Germany and the United Kingdom, and I should like to see the reverse operation, for there is much to be gained by a process of blending in professorial ranks. We want new blood at home. We have made a bold start here by appointing Dr. Henry Bovey, of the McGill University (Montreal), the Rector of our new Imperial College of Technology in South Kensington, and there is every reason to anticipate complete justification for his selection. It is in the behavior of the employers and captains of industry that even a greater characteristic is evident. They, in America, not only appreciate, but assist in noble ways, the acquisition of scientific attainments in their employees. The premium system, such a serious check at home, is abolished, and they select only those who can submit diplomas. They fully recognize the advantage of technical attainments, they encourage research. They equip their own laboratories, and they support college and university by financial help and by the gift of machinery. The lavish supply of apparatus, in every technical school, so marked a feature in American institutions, is thus accounted for, and makes our equipments simply insignificant. The American master recognizes the fact that pupils are best trained by means of the very apparatus that they will have to tend. Even the works in many cases become advanced classes of the college. The marked distinction in American practice is the adoption of the four-years' course—which we certainly ought to adopt at home. Though not specified, or even regulated, it is quite evident that in America all are working on fixed methodical lines, and that gradually a national coordinated system will be evolved which will make the United States the best secularly educated country in the world, and its education policy thoroughly organized.

*From a lecture recently delivered before the Royal Society of Arts, London.

The American has always been impressed with the idea that education is essential to the development of a nation. Land grants were instituted by Congress in 1786 for the maintenance of schools and of a literary institution established by the State. The Great Land Grant Act (Morrell) in 1862 appropriated 13,000,000 acres for this purpose, so that each State should found "at least one college where the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts. . . . in order to promote the liberal education of the industrial classes." The Federal government in 1890 allotted $25,000 a year to each State for this purpose. The total grants of land up to 1900 by the Federal government were for

Schools	67,893,919 acres,
Colleges and universities	10,765,520 "
	78,659,439 acres,

and, in addition, $50,000,000 in money. Fortunately for Americans education has been kept outside politics, and it is not as with us the shuttlecock of party. It is recognized as their greatest national asset, and every citizen regards it as his duty to contribute to its promotion. Each State makes large appropriations for schools and universities, and most of the universities obtain about $500,000 per annum each. There are 17,000 paid professors, lecturers and teachers in the United States. Canada is as liberal, and follows its neighbor and not its mother country in this policy and fashion. The munificence of the millionaire has not been confined to the United States. Canada has her Strathcona, Mount Stephen, Redpath, Molson and Macdonald. Sir W. C. Macdonald has spent over $10,000,000 upon the McGill University alone in the development of scientific and agricultural departments. A smart boy in America can get his education practically given free up to 22 years of age. There is everywhere co-education. There is no residential system at the universities. Accredited pupils can pass from the high schools to the university without an entrance examination. There is a close and almost organic connection between academic and industrial life. Culture is not neglected as with us. Teachers are actively engaged in the practice of their profession. We do this in our medical schools only. Why should not the same be done in our technical schools? We have much to learn from American practice.

INDUSTRIAL EDUCATION

FROM THE VIEWPOINT OF A MANUFACTURER*

By F. A. GEIER

But, while this course [the co-operative course in engineering of the University of Cincinati—Ed.] produces men for the higher positions—superintendents, engineers and designers—I would like to talk with you a little more about educating the great army of workmen that we must employ in our shops.

I claim that this question of industrial education is an economic proposition—as much a part of your business as the purchase of materials, the employment of your salesmen, your advertising men, or your managers. Consider how much time you give to the planning of your shop buildings, the time you spend investigating equipment for your plant, and the careful study you give each machine to determine which one offered will produce the greatest output. The careful attention that American manufacturers have given these matters has been a large factor in putting them into the strong position they occupy to-day. But I ask you in all fairness, how much time, how much careful thought, how much consideration, have you given the subject of labor in your shops? Is it not a fact that you have dismissed that subject largely from your minds and placed it in the hands of superintendents and foremen? What do you know of the feeling toward you of the men in your shops? Have you investigated the conditions under which those men were educated and the limited extent of their education? Are you conversant with the actual relation existing between the foremen and the men in your employment?

*From an address before the National Metal Trades Association, by the President of the Cincinnati Milling Machine Company.

Is it not a fact that we have considered this labor more or less in the same way as we do a piece of machinery? We go out and buy it as we do a small tool and then we forget about it, because our thoughts are centered upon the larger problems of organization of our business, the expansion of our foreign markets, and similar matters which are of more immediate importance than the consideration of the conditions of labor. I ask you again, how much time have you personally given to the sociological side of the manufacturing problem?

Our consuls, importers and manufacturers who are in touch with the situation, seem to have agreed that the successful German invasion of the world's markets is the logical outcome of the greater average efficiency of her workmen.

Referring to the report of the Massachusetts commission on industrial and technical education, I quote the following: "Employers testified that 'manufacturing was becoming more difficult and more expensive'—caused by a lack of skilled workmen. This lack is not chiefly the want of manual dexterity (though such a want is common), but the want of what may be called industrial intelligence. By this is meant mental power to see beyond the task which occupies the hands for the moment, to the operations which have preceded and to those which have followed it—power to take in the whole process, knowledge of materials, ideas of cost, ideas of organization, business sense and a conscience which recognizes obligations. Such intelligence is wise enough to see that the more it has the more it will receive.

"Manufacturers confidently believe that a system of industrial education, wisely planned, would tend to develop such intelligence, while it increased technical skill."

And quoting still further: "Bismarck inquired of the officer in charge of the German exhibit at the Centennial Exposition, in 1876, as to the effect of the comparison of German goods with those of other countries. The reply was: 'Our goods are cheap and wretched.' France stood out at this exposition as superior to all other countries in those manufactured goods which displayed skill and training. Germany took her cue from this, and entered upon a career which has brought her to the front rank in the production of goods both useful and artistic. England took her cue also. Then began the crusade for the establishment of training schools, the inauguration of manual training and industrial education in every direction, and England for a while held her supremacy."

Under the present system of manufacturing we are practically using up our supply of labor. We have not paid any attention at all to finding a new source of supply, nor have we given any thought to its proper training. Our very system of demanding production from the foreman who employs the men eliminates the boy; but we, as manufacturers, are not living in the present day only; we will have to carry on our businesses to-morrow, and next year, and ten years from now, and it certainly would be wise on our part to make such effort as will enable us to recruit labor from new sources of supply and give careful heed to the cultivation of such sources of supply as we now have to make it more efficient.

Origin of the Word "Ingenieur."—A writer in the "Zeitschrift des Oesterr. Ingenieur und Architekten Vereins" has investigated this matter, and some of the results of his researches are very interesting. The earliest occasion on which the profession is referred to is in a Latin book published in the year 1196, the name being given as "Encignerius"; later, in 1238, it again appears in a Latin book as "Izegnerius." The nearest approach to the English word "engineer" is found in a French book published in 1248 as "engingnierre." The profession was at first connected entirely with military operations in the construction of forts. In 1710 Prince Eugen, of Austria, writing to the emperor, complains that "there is not a single engineer in the army who understands how to build a fort." He assumes that "as the engineers are not paid (!) they have either actually come to grief through want of money or else they have moved into other countries to escape ruin." As a result of this state of affairs, engineering schools were established by the emperor at Brussels in 1717, and at Vienna in 1718. The earliest pictorial representation of an engineer found by this investigator was in a rare German book, published in 1751, entitled "Failures among Men," where one of the illustrations is entitled "The Engineer."—"The Surveyor," London.

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NOTES ON ENGINEERING AND APPLIED SCIENCE FROM ALL SOURCES

Automobile Street Sweeper.—A machine of this type has recently been put in operation in Paris, France. It is actuated by a 16-HP. motor and travels from 4 to 6 miles per hour. It is provided with a water tank and pump, by means of which water in the form of a nebula or fine spray is directed on the pavement in advance of the roller broom for the purpose of agglomerating the particles of dust. The amount of water used is very small, being only about 1 gal. for 1,200 sq. ft.of pavement swept.

Alcohol From Peat.—According to a recent consular report the large deposits of peat in this country, which have hitherto been of practically no value, may prove to be of great worth if the recent experiments of a French chemist, Raynaud, in distilling alcohol from peat prove to be practical, as now seems probable. The cellulose of the peat is hydrated and converted by means of sulphuric acid into a soluble carbohydrate, which is fermented by means of a special yeast, which has hitherto been kept secret. According to statements made by Professor Ramsey, one ton of dry peat is said to furnish about 43 gals. pure spirits and about 66 lbs. of sulphate of ammonia of 100%. It is asserted that the manufacturing costs of 1 gal. of alcohol of 97% are at most 10 cents, whereas the cost of the process of distilling from potatoes is about 35 to 40 cents.

A High-Efficiency Oil Engine.—According to a report by Prof. G. Weber in a German contemporary, efficiency tests of a Diesel motor of 200 HP., driving a direct-coupled 3-phase generator in the power plant of the foundry of the L. von Roll Ironworks, at Berne, showed the following results: Fuel used, petroleum residuum. Fuel consumption (in lbs. per KW.-hr. at switchboard), 0.62 at maximum load, 0.62 at rated load, 0.66 at three-quarter rated load, 0.77 at half rated load, 1.42 at quarter rated load. The generator efficiency varied from 91.5% at full load to 77.5% at quarter load, including friction and ventilation losses at 1% of full load. The thermal efficiency based on effective horse-power was computed at 33.6% for rated load, 32.4 for three-quarter load, 28.7% for half load, and 18.7% for quarter load, while the thermal efficiency based on indicated horse-power was 47.3 to 44.1%, being maximum at half load.—"The Mechanical Engineer."

Calculations for Magnetic Clutches.—The number of ampere-turns of excitation required for an ordinary clutch, consisting of a thick disk with an annular space machined out of one face for the magnetizing coil and provided with a flat-faced disk armature of the same diameter, may be calculated from the following equation:

$$\text{Ampere-turns} = 9{,}500{,}000\ LBD\sqrt{B.HP.} + A\mu\sqrt{BN(D^2 + 8RB)},$$

where L = mean length of the magnetic circuit; B = radial width of the annular pole face; D = diameter of central pole face or hub of clutch; B.HP. = brake horse-power to be transmitted; A = mean cross-sectional area of the path of the lines of force; μ = permeability of metal (say 2,500 for wrought iron); N = revs. per min.; R = mean radius of annular pole face [= (outside diameter of clutch — B) ÷ 2]; all dimensions in inches. Thus, assuming R = 4 ins.; D = 2.5 ins.; B = 1 in.; L = 10 ins.; A = 9 sq. ins.; B.HP. = 4; N = 100; and μ = 2,500, ampere-turns of coil = 340. To allow for the reluctance of the joint this should be increased, say, to 400.

Mean Stream Flow Estimates.—In planning for enterprises involving the use of water in streams, the engineer has to base his estimates of the quantity and distribution of the flow that may be expected in the future on records for past years. The flow of a stream is a constantly changing quantity and neither the total quantity nor its distribution for any year will probably ever be the same in any other year. By the study of long series records of flow of the Ohio River at Wheeling, W. Va. (drainage area 23,800 sq. mi.), the Tennessee River near Chattanooga, Tenn. (drainage area 21,400 sq.

mi.), and the Sudbury River at Framingham, Mass. (drainage area 75.2 sq. mi.), it has been found that there occurs in practically each period of 10 years investigated a year of average low water and also of average high water. While this low and high may not be the extreme, it gives nevertheless the mean condition which may be expected with the exception of the abnormal year, which as a rule only occurs once in many years. It is believed, therefore, that a 10-year period will give a fair idea of the flow that may be expected on any eastern stream.—John C. Hoyt, in "Engineering News."

The Shrinkage of Wood.—Experiments by the Forest Service, at its timber testing station at Yale University, show that green wood does not shrink at all in drying until the amount of moisture in it has been reduced to about one-third of the dry weight of the wood. From this point on to the absolutely dry condition, the shrinkage in the area of cross-section of the wood is directly proportional to the amount of moisture removed. The shrinkage of wood in a direction parallel to the grain is very small; so small in comparison with the shrinkage at right angles to the grain, that in computing the total shrinkage in volume, the longitudinal shrinkage may be neglected entirely. The volumetric shrinkage varies with different woods, being about 26% of the dry volume for the species of eucalyptus known as blue gum, and only about 7% for red cedar. For hickory, the shrinkage is about 20% of the dry volume, and for long-leaf pine about 15%. In the usual air-dry condition, from 12 to 15% of moisture still remains in the wood, so that the shrinkage from the green condition to the air-dry condition is only a trifle over half of that from the green to the absolutely dry state.

Superheated Steam Economies.—"A few years ago the author made some experiments on a 300-B. HP. triple-expansion engine with piston valves, the temperature of the superheated steam varying from 0 to 120° C. The results of these trials when exhausting to atmosphere (182 lbs. per sq. in.) show that the consumption per hour of saturated steam, i.e., with no superheat, is 19.5 lbs. per brake horsepower, whereas it falls to 12.75 lbs. at a temperature of 608° F., equivalent to a superheat of 216° F.

"The saving therefore amounts to (19.5 — 12.75)/19.5 = 35.5%.

"When exhausting to condenser (214 lbs. per sq. in.), the consumption per brake horsepower falls from 16 lbs. with no superheat to 10.5 lbs. with a superheat of 216° F., or a saving of (16 — 10.5)/16 = 32%.

"The amount of reduction in steam consumption depends, of course, upon the design of the engine under consideration; in the present case it amounts to about 1% for every 7.2° F. of superheat. This is a figure frequently given, and which the author has been able to verify elsewhere."—Felix F. T. Godard, in a paper read before the Institution of Naval Architects, April 8, 1908.

Steel Belts for Power Transmission.—For the purpose of replacing the ordinary belt and rope transmission, a Berlin firm has recently brought out a form of thin steel band running either on ordinary bare pulleys or on pulleys faced with a special preparation. Considerable saving in width of pulley results through the use of these steel bands. Thus, the width of an ordinary belt for a 200-H.P. engine driving a dynamo at a peripheral speed of 5,300 ft. per min. would be about 24 ins., whereas the steel belt used was but 4 ins. wide (0.02 in. thick). This reduction is especially advantageous in the case of overhung pulleys, as it not only reduces the length of shaft but also the leverage of the unbalanced belt pull. The steel band also enables very short drives to be used, and so reduces the floor space required in many cases. The ends of the bands are joined by a special lock, having its inner surface rounded to the radius of the smaller pulley. The band does not stretch in use, so that the pulley distances can be fixed once for all at the start. This absence of stretch also reduces the apparent slip which occurs with ordinary belts, owing to the expansion of the belt whilst moving over the driven pulley and its compression while on the driving pulley. This slip is only about 0.1% with the steel bands. Very high peripheral speeds are allowable with the new belts, and experiments have been carried out at speeds up to 12,000 ft. per min.

The Lift of Aeroplanes.—Draw a right-angled triangle, denoting the base by A C and the vertical height by B C. The angle B A C is then the inclination of the plane to the line of flight in still air, and the height B C corresponds to the pitch of a screw. Suppose we assume B C to be one-fourth of A C, say 1 ft. and 4 ft. respectively; the plane will then

move the air downwards 1 ft. for every 4 ft. of travel. Assume the speed to be 44 ft. per second; in one second therefore the air will be moved 44/4 = 11 ft. V, the acceleration, therefore equals 11 ft. per second.

The total quantity of air moved per second is found by taking the sum of the lengths of all the leading edges of the planes. This sum multiplied by the distance moved in one second and by 0.08 and by V will give us the weight of air moved, and this weight multiplied by V and divided by 32 (g) will give the thrust, or lift, in pounds. If S = speed per second in feet on the line of flight, P the pitch = A C/B C and V the acceleration = S/P, and L = length of the leading edges, we may write the formula as $0.08 \, L \, S \, V^2/32$ = the lift in pounds.

In Farman's case the speed S was 45 ft. per second, L equaled about 96 ft.—we do not know what V was, but assume it to be 10 ft.—we get lift or thrust, $T = 96 \times 45 \times 10^2 \times 0.08/32 = 1{,}080$ lbs. It was actually 1,100 or thereabout.—Prof. Rankin Kennedy, in "Engineering."

The Hygienics of Gas and Electricity as Illuminants.—In a paper recently read before the Royal Sanitary Institute of London by Dr. Samuel Rideal, the results and conclusions derived from a number of interesting experiments are given. The investigations were carried out to determine the respective physiological effects due to lighting by gas and by electricity. The main conclusions may be summed up as follows:

1. Owing to the better ventilation obtained by gas, the products of combustion are not found in the air in the proportion which might be expected, the temperature and humidity in an occupied room being no greater than when the room is lit with electric light.

2. Carbonic acid has not the injurious effect which was formerly attributed to it, but considerable rises in the temperature and moisture content of a room, from whatever source, do have a prejudicial effect upon the well-being of the occupants. Even under adverse conditions of ventilation, purposely created for this inquiry, neither the temperature nor percentages of moisture in the room reached a point at which any such effect could be detected by any of the recognized physiological tests.

3. It has been established that the products, viz., heat, carbonic acid and moisture, so far as they modify the health of the occupants of a room, are derived from the inmates more than from the illuminant, and that a room of moderate size can be efficiently lighted by gas without sensibly affecting the amount of these three factors.

4. While undoubtedly it is important to ensure adequate ventilation in domestic rooms, this, with present methods of construction, is better ensured the smaller the room.

5. The medical conclusions are in accord with those arrived at from the chemical and physical data, and also demonstrate that the choice between the two systems of lighting does not depend upon hygienic considerations.

Irregularities in Cement Analysis.—The "British Clayworker," in a recent issue, calls attention to the need for a standard method of cement analysis, showing the importance of doing away with the irregularities resulting from the different methods employed in various laboratories. The experience of a German firm is quoted as an extreme example of how great differences may result from variations in the methods of analysis. The firm stated that the cement to be used on a large work should conform to the standard French specifications. The work was begun, and on investigation it was found that the sample, according to the analysis made in the works laboratory, contained over 4% of iron oxide, which was in excess of the amount allowed by the specification. Samples were then sent to the chief testing laboratories in Berlin, Wiesbaden, Zürich, Paris and Madrid. The results obtained showed a wide variation in the percentage of the various constituents. The Paris laboratory gave the percentage of iron oxide as 3.10 while the Berlin analysis stated it to be 4.48; 19.36 was given by the Madrid laboratory as the percentage of silica, while the Paris analysis showed 21.34% for this constituent. The Zürich results found Al_2O_3 to be 8.51%, while the Berlin analysis gave the percentage of alumina as 6.57. The Madrid laboratory found the SO_3 content to be 1.46, and the Paris results showed only 0.62 for this constituent. These were the most important differences, though in no case was there even a reasonably good uniformity exhibited. Furthermore, the Zürich laboratory's results were wrong on their face, for they totaled 101.81 instead of 100.00. The results obtained by the German laboratories, presumably using the same methods, might have been expected to vary somewhat from those of the Paris and Madrid laboratories, but they did not even

agree with each other. Serious litigation may result from such a lack of uniformity and it certainly would seem that the adoption of a standard method would be a wise step.

The Strength of Chain Links.—A series of experiments on chain links and circular rings, covering a period of two years, has been recently completed at the Engineering Experiment Station of the University of Illinois by G. A. Goodenough, Associate Professor of Mechanical Engineering, University of Illinois, and L. E. Moore, Assistant Professor of Civil Engineering, Massachusetts Institute of Technology, formerly instructor at Urbana. The work was undertaken for the purpose of confirming or disproving a theoretical analysis of the stresses in links and rings. A comparison of calculated and measured deflections afforded the desired test, and the results of the investigation abundantly confirmed the analysis. A reliable theory having been derived, the bending moments and maximum stresses were calculated for links of various forms, and the results of such calculations were applied to the formulas for the loading of chains given by Unwin, Bach and Weisbach. These latter are of the form $P = kd^2$, where P is the load in pounds, d the diameter of the link in inches and k a constant varying from 11,000 to 18,000. In the formulas given by these authorities, however, the maximum stress to which the link is subjected seems to be under-estimated, the values of k being such as to give maximum tensile stresses of from 33,000 to 40,000 lbs. per sq. in., and maximum compressive stresses of about 60,000 lbs. per sq. in. The formulas arrived at by the authors are:

$$P = 0.4d^2S, \text{ for open links, and}$$
$$P = 0.5d^2S, \text{ for stud links,}$$

where S denotes the maximum permissible tensile stress in lbs. per sq. in. If S is taken at 15,000, the corresponding values in the earlier formula for k are 6,000 and 7,500, respectively, for open and stud links. The investigation is described at length in a 72-page bulletin (No. 18) published by the university, and the theoretical discussion which was the basis of the experimental work is given in full in appendixes. Copies of the bulletin may be obtained upon application to the Director, Experimental Station, Urbana, Ill.

Steam vs. Compressed Air for Power Hammers.—Although compressed air possesses certain advantages over steam for operating power hammers, the sweeping statement sometimes met with that the former is the more economical in steam hammers does not seem to be confirmed upon investigation. Messrs. B. & S. Massey, a prominent English firm of pneumatic and steam-power hammer makers, have recently published tables which throw considerable light on the subject. The properties of steam and compressed air are so nearly alike that it is safe to say that the same amount of work can be done in a hammer cylinder by a given volume of each, measured at the same pressure. From the data in Messrs. Massey's tables it would seem that as regards the cost of power it is more economical to use steam than compressed air. For instance, if the figures for 60 lbs. steam pressure be compared with those for 45 lbs. air pressure—the latter being regarded by the authors as the most economical air pressure to work at—with reference to a works where coal is obtainable for $2.40 per ton, and electric current costs 2 cts. per KW.-hr., or belt power 1.76 cts. per B.HP.-hr., the cost will be as 22.6 is to 99; or, stated otherwise, the cost of steam driving will be less than one-quarter of that of air operating. On the other hand, in a works which has to pay $4.20 per ton for fuel and only 0.5 ct. per KW.-hr. for electric energy, or 0.44 ct. per B.HP.-hr. for belt driving, air comes out the cheaper (36.6:25). Broadly, however, it may be calculated that the cost of driving by steam and air will be about the same in a works where coal costs $6 per ton and electric power 1 ct. per KW.-hr., or belt power 0.88 ct. per B.HP.-hr. (In these calculations it is assumed that 5 lbs. of steam will be delivered to the hammer per pound of coal burned, allowing for average boilers a loss by condensation in pipes of 2½ lbs. Fifty cents per ton is included in the prices given for coal for labor and boiler maintenance.)—"The Engineer," London.

BOOK DEPARTMENT

THE ENGINEERING DIGEST BOOK CLUB

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THERMODYNAMICS OF TECHNICAL GAS REACTIONS.—By Dr. F. Haber, Professor at the Technische Hochschule, Carlsruhe. Translated by Arthur B. Lamb, Director of the Havemeyer Chemical Laboratory, New York University, New York City. New York and London: Longmans, Green & Co. Cloth; 5¾ x 8¾ ins.; pp. xix. + 356; 20 illustrations. $3 net.

This work consists of a series of seven lectures delivered before several of the colleagues of the author and a number of young research students in the early part of 1905. In them the author endeavored to make clear the significance of heat factors in gas reactions, with especial reference to the specific heats of the interacting substances and to the heat evolved during the reaction. The gathering of these lectures into book form has been for the purpose of effecting a contribution to technical, rather than to theoretical, chemistry, and the aim of the author has been to present in the clearest manner the application of the mechanical theory of heat to chemistry. Professor Haber thoroughly revised the German edition purposely for this translation, and many parts were rewritten in order to include matter necessitated by the progress made during the years 1905 and 1906. The subjects of the various lectures are as follows: The Latent Heat of Chemical Reaction and Its Relation to Reaction Energy; Entropy and Its Significance in Gas Reactions; Examples of Reactions which Proceed Without a Change in the Number of Molecules; Examples of Reactions Involving a Change in the Number of Molecules; The Determination of the Specific Heats of Gases; The Determination of Gaseous Equilibria, with a Theoretical and Technical Discussion of Related Questions; Appendixes. It is a work that will thoroughly interest chemical engineers and metallurgists.

METHODS FOR EARTHWORK COMPUTATIONS.—By C. W. Crockett, Professor of Mathematics and Astronomy, Rensselaer Polytechnic Institute. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp x + 114; 90 figures in the text. $1.50 net.

In this book the author has sought to formulate a series of rules by means of which the terms requisite for the numerical computation of volumes by the prismoidal formula and the average end area method may be written directly from the notes, without any intermediate steps and without drawing any figures, the symbolized form of the rules enabling the computer to apply them without difficulty. In the third chapter is determined the correction to be subtracted algebraically from the volume obtained by the average end area method in order to find the volume as it would be given by the prismoidal formula. Chapter IV. treats of the determination of the volume by the average end area method when the transverse slope of the surface is measured; and the resulting formulas are so systematized that the volumes in side-hill work, as well as in through work, may be readily computed. The succeeding chapter deals with the correction for curvature in railroad work, and is followed by one describing a slide rule invented by the author for the computation of volumes, and giving instructions for its use. Appendixes are included on the hyperbolic paraboloid and the general applicability of the prismoidal formula; approximate prismoidal correction in railroad work; and a

summary in which the rules developed in the text are stated in a manner that, it is believed, will render their application in practice simple and rapid, with little chance of error.

PRACTICAL HYDRAULIC (WATER SUPPLY AND DRAINAGE) TABLES AND DIAGRAMS.—By C. E. Housden, Superintending Engineer, P. W. D., India. New York and London: Longmans, Green & Co. Cloth; 5 × 7 ins.; pp. xii. + 112; 14 figures and diagrams. $1.25.

These tables and diagrams, originally prepared for the personal use of the author, have proved of such use and convenience in ascertaining the sizes of pipes for water supply systems, surface drains and sewers, that they have been published in the present form. By their aid, if the total length in feet of a long line of continuous pipes to provide different discharges and the levels in feet from point of discharge of the last pipe to the water surface of source of supply are known, the required sizes of the different pipes can be at once determined from their average hydraulic gradients, irrespective of the length or slope of each individual pipe, also sizes of drains and sewers can be found from the falls in their water surfaces. The tables are based on Ganguillet & Kutter's formula, and the system of calculation is thought by the author to be original with him.

EDUCATIONAL WOODWORKING FOR HOME AND SCHOOL.—By Joseph C. Park, of the State Normal and Training School, Oswego, N. Y. New York: The Macmillan Co. Buckram; 4⅞ × 7⅛ ins.; pp. xii. + 310; 263 figures and illustrations. $1, net.

This book has been prepared for the purpose of supplying a text-book for the use of pupils in the manual training work of public schools. The various woodworking tools and machines are clearly described and illustrated and their uses pointed out. Woods are then briefly studied, an appendix, however, amplifying this chapter, being devoted to a descriptive listing of the more important woods of North America. Sections are also included on fastening devices, such as nails, screws, glue, dowels, keys etc., and on filling, staining and varnishing Wood turning is discussed in a chapter of 30 pages, and a large variety of exercises are given for knife work, joinery, cabinet making and turning. The commoner geometric problems and tables of weights and measures form the subject matter of two appendixes. Under a capable instructor the work should prove of undoubted educational value.

REFRIGERATION.—An Elementary Textbook. By J. Wemyss Anderson, M. Eng., M. Inst. C. E., M. L. Mech. E. New York and London: Longmans, Green & Co. Cloth; 5½ x 8½ ins.; pp. ix + 242; 87 illustrations, including 4 folding plates. $2.25 net.

This work is devoted to an exposition of the scientific principles involved in the production of low temperatures, and to descriptions of the apparatus by which they are obtained. The work being an elementary one, questions relating to the design of apparatus have been properly withheld for a succeeding and more advanced volume. The first three chapters are given up to a concise study of heat and its effects, thermometers, sources of heat, energy, specific and latent heat, and the transfer of heat by radiation, conduction and convection. Chapters IV. and V. deal with the properties of fluids, the expansion and compression of gases and vapors, including tables of the properties of the various liquids and vapors employed in refrigerative work. Chapter VI. discusses the basic laws of thermodynamics, Carnot's cycle, efficiency and the coefficient of performance of a perfect refrigerator. In Chapter VII. is given a general outline study of the various types of refrigerating machines, in which cold air and vapor machines are described and details given of compression machines and absorption plants. Chapter VIII. is devoted to water and brines and their properties, as well as to air and its humidity. The succeeding chapter discusses the various methods of manufacturing artificial ice. Chapter X. describes the construction and insulation of cold-storage warehouses and rooms, and the different methods of cooling used. The last two chapters treat of a number of miscellaneous uses of refrigeration, such as the cooling of buildings, shaft sinking through water-bearing rock or earth, regulating the moisture in the air supply to blast furnaces, brewery refrigeration, cold storage and the temperatures required, etc. The illustrations are good, the index is ample, and many instructive and practical problems are given in their proper place for the further use of the student.

HOW TO USE SLIDE RULES.—By D. Petri-Palmedo. New York: Kolesch & Co. Flexible cloth, 4 × 7 ins.; pp. 56; illustrated. $0.50.

To the novice, unfamiliar with the mysteries of the slide rule, this little work will undoubtedly prove useful. Simple examples are at first given and the student is gradually led u;

to the performance of the more difficult manipulations. The author's style is clear and his expositions will be easily understood. After a prefatory chapter the author describes the Mannheim slide rule and describes the methods of graphical addition and subtraction. The following subjects are then taken up in the order named: the logarithmic scale, multiplication, division, proportions, continued multiplication and combined multiplication and division, squares, square roots, cube roots, logarithmus, powers and roots, trigonometrical functions, the trigonometric functions in calculations, tangents smaller than 0.1, sines smaller than 0.01, compound calculations and the triplex slide rule.

PRACTICAL EARTHWORK TABLES.—By C. E. Housden, Superintending Engineer, P. W. D., India. New York and London: Longmans, Green & Co. Cloth; 5 × 7 ins.; pp. viii. + 53; 9 diagrams. $0.90.

These tables have been prepared for the purpose of facilitating the computation of the cross-sectional areas of embankments and excavations, by reducing the work involved in preparing special sections and in making the necessary calculations from longitudinal and cross-sections of ground over or through which the proposed bank or cut has to be made. Where the ground at right angles to the center line is fairly level, or of uniform slope, the preparation and calculation of special cross-sections may be entirely avoided by the use of the tables. Where the cross slope at the selected points is not the same for all of them, the calculation of cross-sectional areas is necessary, but is much simplified by using the tables. One method of obtaining the cubic contents of an embankment or cut from the tables allows the approximate amount of progress at any particular time to be quickly ascertained, and affords an easily applied check on the work as well as on borrow-pit measurements.

BUNGALOWS, CAMPS AND MOUNTAIN HOUSES.—Selected and Compiled by the Editor of "The Architects' and Builders' Magazine." New York: W. T. Comstock. Illuminated boards; 7½ x 10 ins.; pp. 111; profusely illustrated. $2 net.

This book consists of plans, half-tone reproductions of photographs and pen sketches of a large variety of designs by a number of architects, showing buildings that have been erected in all parts of the country. Many of these are intended for summer use, while other examples are of structures erected in California and the Southern States for permanent residences. Camps, hunters' lodges and log cabins are also included, suitable for vacation use in woods and mountains. Descriptions of the designs are given in the letter press, costs in many instances being stated. The book is excellently printed on fine coated paper and will be found full of suggestions to those contemplating the erection of the informal structures it describes.

AIRSHIPS, PAST AND PRESENT.—Together With Chapters on the Use of Balloons in Connection with Meteorology, Photography and the Carrier Pigeon. By A. Hildebrandt, Captain and Instructor in the Prussian Balloon Corps. Translated by W. H. Story. New York: D. Van Nostrand Co. Cloth; 6 × 9 ins.; pp. 364; 222 text illustrations. $3.50, net.

The modern application of ballooning to scientific purposes and the development of the dirigible balloon and the airship have aroused a widespread interest on the part of the public in this form of sport. The author of this work, believing that the present moment was suitable for a review of the history and present state of development of airships in general has presented such a survey in this work. In it are discussed all questions relating to ballooning which lend themselves to popular treatment and are of general interest. The introduction of occasional theoretical considerations was, of course, unavoidable, but these have been reduced to the smallest possible compass. The avoidance of technical discussions makes the book easy and pleasant reading for anyone who is interested in the subject. The sections on dirigible balloons, military ballooning, balloon photography and the use of carrier pigeons in connection with military ballooning are of especial interest.

NEW BOOKS.

Civil Engineering.

A TREATISE ON THE PRINCIPLES AND PRACTICE OF HARBOR ENGINEERING.—By Brysson Cunningham, Author of "Dock Engineering," etc. London, England: Charles Griffin & Co., Ltd. Philadelphia, Pa.; J. B. Lippincott Co. Cloth; 6¼ x 9¼ ins.; pp. 283; 248 illustrations, mostly in the text. $5.00, net.

CONCRETE CONSTRUCTION.—Methods and Cost. By Halbert P. Gillette, M. Am. Soc. C. E., M. Am. Inst. M. E., Managing Editor, Engineering-Contracting, and Charles S. Hill, C. E., Associate Editor, Engineering-Contracting. New York and Chicago: The Myron C. Clark Publishing Co. Cloth; 6 x 9¼ ins.; pp. 690; 306 illustrations in the text and 37 tables. $5.00, net.

SECONDARY STRESSES IN BRIDGE TRUSSES.—By C. R. Grimm, M. Am. Soc. C. E. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5½ x 9¼ ins.; pp. 140; 60 illustrations in the text and 15 tables. $2.50; English price, 10s. 6d., net.

Marine Engineering.

MARINE BOILER MANAGEMENT AND CONSTRUCTION.—Being a Treatise on Boiler Troubles and Repairs, Corrosion, Fuels and Heat, on the Properties of Iron and Steel, on Boiler Mechanics, Workshop Practices and Boiler Design. By C. E. Stromeyer, M. Inst. C. E., Chief Engineer of the Manchester Steam Users' Association. Third Edition. New York, London and Bombay: Longmans, Green & Co. Cloth; 6 x 9¼ ins.; pp. xx. + 404; 452 illustrations in the text and many tables. $4, net; United Kingdom, 12s. 2d., net.

Materials.

THE PRINCIPAL SPECIES OF WOOD.—Their Characteristic Properties. By Charles H. Snow, Dean of the School of Applied Science, New York University. Second edition, revised, with additions. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 x 9 ins.; pp. xi. + 203; with numerous figures in the text and 37 full-page half-tone plates. $3.50.

Mathematics.

A VEST-POCKET HANDBOOK OF MATHEMATICS FOR ENGINEERS.—By L. A. Waterbury, C. E., Professor of Civil Engineering, University of Arizona. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Morocco; 2⅞ x 5⅝ ins.; pp. vi. + 91; 61 figures. $1.00, net.

Mechanical Engineering.

MACHINE DESIGN, CONSTRUCTION AND DRAWING.—A Text Book for the Use of Young Engineers. By Henry J. Spooner, M. Inst. M. E., Assoc. M. Inst. C. E., Director and Professor of Mechanical and Civil Engineering in the Polytechnic School of Engineering, Regent St., London, Author of "The Elements of Geometrical Drawing," etc. London, New York and Bombay: Longmans, Green & Co. Cloth; 5½ x 8¾ ins.; pp. 691; 5 plates; 1,433 text illustrations and 86 tables. $3.50.

POWER GAS PRODUCERS.—Their Design and Application. By Philip W. Robson, of the National Gas Engine Co., Ltd. London, England: Edward Arnold. Cloth; 5½ x 8¾ ins.; pp. 247; 105 illustrations, mostly in the text, and 31 tables. $3.00, net.

REPORT OF THE UNITED STATES FUEL-TESTING PLANT AT ST. LOUIS, MO.—Jan. 1, 1906, to June 30, 1907. Joseph A. Holmes, In Charge. Bulletin No. 332, U. S. Geological Survey. George Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ x 9 ins.; pp. 299; numerous tables.

Mining and Metallurgy.

A POCKET HANDBOOK OF MINERALS.—Designed for Use in the Field or Class-room, with Little Reference to Chemical Tests. By C. Montague Butler, E. M., Assistant Professor of Geology and Mineralogy, Colorado School of Mines; United States Deputy Mineral Surveyor. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Leather; 4 x 6½ ins.; pp. ix. + 298; 89 figures. $3.00.

COAL-MINE ACCIDENTS: THEIR CAUSES AND PREVENTION.—A Preliminary Statistical Report. By Clarence Hall and Walter O. Snelling. With Introduction by Joseph A. Holmes, In Charge of Technologic Branch. Bulletin No. 333, U. S. Geological Survey. George Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ x 9 ins.; pp. 21.

INTRODUCTION TO METALLOGRAPHY.—By Paul Goerens, Docent in Physical Metallurgy at the Royal Technical High School, Aachen. Translated by Fred. Ibbotson, A. R. C. Sc. I., Lecturer in Metallurgy, The University Sheffield. London and New York: Longmans, Green & Co. Cloth; 5¾ x 9 ins.; pp. 214; 158 illustrations in the text. $2.50, net.

Sanitation.

THE SANITATION OF RECREATION CAMPS AND PARKS.—By Dr. Harvey B. Bashore, Medical Inspector for Pennsylvania Department of Health. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5 x 7½ ins.; pp. xii. + 109; 19 full-page half-tone plates. $1.00.

Two important consolidations of technical journals take effect the first of the present month. "The Railroad Age Gazette" is the title under which the successor to the "Railroad Gazette" and "The Railway Age" will appear, while the merger by the McGraw Publishing Co. of the "Street Railway Journal" with the "Electric Railway Review" will be known as the "Electric Railway Journal." These new journals will be published in New York City, but the Chicago editorial offices of the "Age" and "Review" will still be maintained.

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INDUSTRIAL ENGINEERING
A JOURNAL OF COST, OPERATING AND PRODUCTION CONTROL

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1 METHOD FOR MEASURING TIME for Repetitive Operations
The most accurate method for measuring time for repetitive operations is by the use of a stopwatch. Here are some tips on how to use it.

4 METHOD FOR MEASURING TIME for Non-Repetitive Operations
Time standards for non-repetitive operations are usually set by the use of estimated times. Here is a method for setting standards by the use of elemental data.

7 WORK SAMPLING
Work sampling is a statistical technique for determining the proportion of time spent in the various activities that constitute a job or task. Here is a discussion of the method.

10 WORK SIMPLIFICATION
Work simplification is a management technique for analyzing and improving the way work is done. Here is a discussion of the method.

13 WORK MEASUREMENT
Work measurement is the application of techniques designed to establish the time for a qualified worker to perform a specified job at a defined level of performance. Here is a discussion of the method.

16 PLANT LAYOUT
Plant layout is the arrangement of facilities for the production of goods. Here is a discussion of the method.

19 MATERIAL HANDLING
Material handling is the movement of materials in the proper amount, to the proper place, in the proper position, in the proper sequence, and by the proper method. Here is a discussion of the method.

22 PRODUCTION CONTROL
Production control is the planning and controlling of the production process to assure that the right quantity of the right product is manufactured at the right time. Here is a discussion of the method.

25 QUALITY CONTROL
Quality control is the use of statistical techniques to control the quality of a product. Here is a discussion of the method.

28 INDUSTRIAL ENGINEERING
Industrial engineering is concerned with the design, improvement and installation of integrated systems of men, materials and equipment. Here is a discussion of the method.

Fig. 1. Portable compressor for use with air tools, mounted on a 4-wheel trailer. The engine is a 4-cylinder, 4-cycle, water-cooled gasoline unit, with a capacity of 210 cu. ft. of free air per minute. The compressor is a single-stage, 2-cylinder unit, with a capacity of 210 cu. ft. of free air per minute. The compressor is driven by a belt from the engine. The compressor is mounted on a 4-wheel trailer. The compressor is provided with a receiver tank of 5 cu. ft. capacity. The compressor is provided with a pressure regulator and a safety valve. The compressor is provided with a lubricator for the air cylinders. The compressor is provided with a water jacket for the cylinders. The compressor is provided with a fuel tank of 10 gallons capacity. The compressor is provided with a starting crank. The compressor is provided with a tool box. The compressor is provided with a hose reel. The compressor is provided with a pressure gauge. The compressor is provided with a thermometer. The compressor is provided with a speedometer. The compressor is provided with a clock. The compressor is provided with a horn. The compressor is provided with a headlight. The compressor is provided with a taillight. The compressor is provided with a license plate holder. The compressor is provided with a fender. The compressor is provided with a mudguard. The compressor is provided with a spare wheel. The compressor is provided with a jack. The compressor is provided with a wrench. The compressor is provided with a screwdriver. The compressor is provided with a hammer. The compressor is provided with a pliers. The compressor is provided with a file. The compressor is provided with a chisel. The compressor is provided with a punch. The compressor is provided with a drill. The compressor is provided with a reamer. The compressor is provided with a tap. The compressor is provided with a die. The compressor is provided with a gauge. The compressor is provided with a micrometer. 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A steel wheel roller for road work, with a capacity of 10 tons. The roller is driven by a 4-cylinder, 4-cycle, water-cooled gasoline engine. The roller is provided with a steering wheel and a seat for the driver. The roller is provided with a water tank of 100 gallons capacity. The roller is provided with a fuel tank of 20 gallons capacity. The roller is provided with a starting crank. The roller is provided with a tool box. The roller is provided with a hose reel. The roller is provided with a pressure gauge. The roller is provided with a thermometer. The roller is provided with a speedometer. The roller is provided with a clock. The roller is provided with a horn. The roller is provided with a headlight. The roller is provided with a taillight. The roller is provided with a license plate holder. The roller is provided with a fender. The roller is provided with a mudguard. The roller is provided with a spare wheel. The roller is provided with a jack. 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Fig. 1.—Ransomes Ploughing Engine.

Steam Power.—Between 1850 and 1870 the application of steam power to agriculture was developed in a number of ways. Ploughing engines were introduced, and the first practical engine was made by Fowler in 1858. Ransomes, Sims & Jefferies also made a ploughing engine in 1858. The latter is illustrated in Fig. 1. The engine was placed at one end of the field and a set of ploughs at the other. The ploughs were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

Fig. 2.—Fowler Steam Cultivator, 1870.

Steam Cultivation.—Fowler's steam cultivator, which was introduced in 1870, is shown in Fig. 2. It consisted of a set of cultivating implements which were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The drum and the pulley were mounted on the frame of the implements. The engine was placed at one end of the field and the implements at the other. The engine was moved from one end of the field to the other by means of a wire rope passing round a pulley at the end of the field and attached to the engine. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

Fig. 3.—Fowler Steam Cultivator, 1870.

Steam Cultivation.—Fowler's steam cultivator, which was introduced in 1870, is shown in Fig. 3. It consisted of a set of cultivating implements which were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The drum and the pulley were mounted on the frame of the implements. The engine was placed at one end of the field and the implements at the other. The engine was moved from one end of the field to the other by means of a wire rope passing round a pulley at the end of the field and attached to the engine. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

Fig. 4.—Fowler Steam Cultivator, 1870.

Steam Cultivation.—Fowler's steam cultivator, which was introduced in 1870, is shown in Fig. 4. It consisted of a set of cultivating implements which were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The drum and the pulley were mounted on the frame of the implements. The engine was placed at one end of the field and the implements at the other. The engine was moved from one end of the field to the other by means of a wire rope passing round a pulley at the end of the field and attached to the engine. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

Fig. 5.—Fowler Steam Cultivator, 1870.

Steam Cultivation.—Fowler's steam cultivator, which was introduced in 1870, is shown in Fig. 5. It consisted of a set of cultivating implements which were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The drum and the pulley were mounted on the frame of the implements. The engine was placed at one end of the field and the implements at the other. The engine was moved from one end of the field to the other by means of a wire rope passing round a pulley at the end of the field and attached to the engine. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

Fig. 6.—Fowler Steam Cultivator, 1870.

Steam Cultivation.—Fowler's steam cultivator, which was introduced in 1870, is shown in Fig. 6. It consisted of a set of cultivating implements which were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The drum and the pulley were mounted on the frame of the implements. The engine was placed at one end of the field and the implements at the other. The engine was moved from one end of the field to the other by means of a wire rope passing round a pulley at the end of the field and attached to the engine. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

Fig. 7.—Fowler Steam Cultivator, 1870.

Steam Cultivation.—Fowler's steam cultivator, which was introduced in 1870, is shown in Fig. 7. It consisted of a set of cultivating implements which were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The drum and the pulley were mounted on the frame of the implements. The engine was placed at one end of the field and the implements at the other. The engine was moved from one end of the field to the other by means of a wire rope passing round a pulley at the end of the field and attached to the engine. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

Fig. 8.—Fowler Steam Cultivator, 1870.

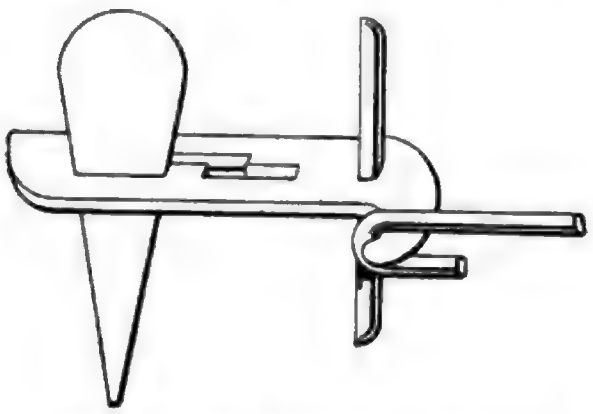
Steam Cultivation.—Fowler's steam cultivator, which was introduced in 1870, is shown in Fig. 8. It consisted of a set of cultivating implements which were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The drum and the pulley were mounted on the frame of the implements. The engine was placed at one end of the field and the implements at the other. The engine was moved from one end of the field to the other by means of a wire rope passing round a pulley at the end of the field and attached to the engine. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

Fig. 9.—Fowler Steam Cultivator, 1870.

Steam Cultivation.—Fowler's steam cultivator, which was introduced in 1870, is shown in Fig. 9. It consisted of a set of cultivating implements which were drawn backwards and forwards by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field. The drum and the pulley were mounted on the frame of the implements. The engine was placed at one end of the field and the implements at the other. The engine was moved from one end of the field to the other by means of a wire rope passing round a pulley at the end of the field and attached to the engine. The engine was moved by means of a wire rope passing round a drum on the engine and a pulley at the other end of the field.

effective method of securing and holding in an upright and properly spaced position the boards or other material selected as forms.

In brief, it consists of pivoted clamps which hold the form boards in position, by means of tie wires, placed in the hook end of clamps. By means of steel wedges placed through the slotted ends of clamps, the boards are held firmly in position. After the concrete has set, and the wedges have been removed, so that



THE DIETRICHS WALL-FORM CLAMP.

the form boards can be taken down, it is an easy matter to disengage the clamp from the wires by working slightly with the hand the end of the pivot arm, which opens the jaw of the clamp, allowing the lip to be pulled out without disturbing in any way the wire, which then forms a reinforcing rod. Small holes left by disengaging the clamp are easily grouted.

A special and unique feature of the use of the Dietrichs clamp—aside from the ease with which the forms may be erected—lies in the fact that the lower board of the forms in which the clamps are used may be disengaged and used to build the forms higher, without in any way disturbing the arrangement or security of the upper boards. This feature allows of not only ease in handling a smaller amount of lumber, for form work, but, it is stated, effects a larger economy than is possible by the use of any other wall form clamp on the market.

The fact that it is possible to remove the lower form boards, while the concrete is still damp, gives additional value to the use of the Dietrichs clamp, as it is possible by this means to effect a positive adherence of the cement used in any grouting which may be necessary where irregularities appear.

No special preparation to fit the clamps to any available timber is necessary beyond the boring of slotted holes in the boards at intervals of about one foot, although it is only necessary to insert the clamps at distances varying from 16 ins. to 4 ft., depending upon the scope of the operation and thickness of the wall.

Any timber which is found available for use in forms where the forms are made with the aid of framework, braces, etc., will be found equally fitting for use with the Dietrichs clamp. In other words—the very material which is ordered for use as floor beams may be used as material for forms, and after serving their function in this direction, may be used for the purpose for which they were originally purchased.

It is claimed for the Dietrichs clamp:

1. That the cost of forms in many cases is done away entirely by using material purchased for use in the construction of the house; and where it is necessary to purchase extra material for forms, a saving of fully 75% over ordinary methods is effected.

2. That an economy of time consumed in the operation of building forms of fully 75% is effected over ordinary methods.

These savings reduce the expense for material and time in constructing form work to 25% of its usual cost.

This device is manufactured and sold by the Dietrichs Clamp Co., 16 Kaufman Ave., Little Ferry, N. J., who will promptly furnish additional information to those interested.

A NEW HARDNESS TESTING INSTRUMENT.

Hardness is that property of a material which resists a change in the relative position of the molecules of the material without separating them from each other. It may be tested and recorded as the resistance to indentation.

If indentations are made in various substances by the same force transmitted through the same medium, the relative hardness of the different materials can be recorded by measuring the depth of the indentation in each. However, the accurate measuring of the depth of such indentation is difficult work and requires special instruments and test pieces. To overcome this difficulty a method must be pursued which will provide a means of quickly and accurately determining the resistance to indentation of a material, such as that accomplished by the Ballentine Method and Apparatus.

The method employed by Mr. Ballentine consists in allowing a hammer or specified weight

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to fall through a specified height (as obtained by experiment) on an anvil to which is connected a test pin which rests on specimen to be tested. A penetration in the material is obtained and resistance encountered is measured by the blow being transmitted to the test pin through a soft metal recording disk which is held at lower end of drop hammer. This soft disk thus offers a constant resistance to deformation and will be penetrated to a depth varying as the resistance the pin encounters in penetrating the material being tested.

In other words, the depth of penetration of the lead recording disk will vary as the hardness of the material being tested and the harder the metal, the deeper the penetration will be in the recording disk.

The instrument is entirely self-contained, and is well adapted to either laboratory or general shop use. It can be used to test all materials used in the various mechanic arts that can be tooled or machined, except those that require an abrasive substance for their reduction, such as hardened steel, which is too hard for indentation.

The Ballentine apparatus is manufactured by Tinius Olsen & Co., Philadelphia, Pa., from whom additional particulars can be obtained upon request.

FOR THE FILE.

Catalogs and literature of machinery, tools and supplies used by engineers, contractors, etc., should always be on hand for reference. When writing the manufacturer or dealer whose catalogs have been reviewed or advertised in the Engineering Digest, please state that you saw the same mentioned in this magazine.

ROCK DRILLS.—Wood Drill Works, 30-36 Dale Avenue, Paterson, N. J. Paper; 6 x 9 ins.; 28 pages; illustrated.

This catalogue describes "Wood" percussive rock drill, which is made in nine sizes, ranging from 2 ins. to 3⅝ ins. Extreme simplicity of construction and durability under hard usage are claimed for this line of drills. The front head, which has always been a source of trouble to manufacturers, is made of malleable iron, held firmly by four bolts instead of only two, and the head is cored from the inside to receive two case-hardened bolts to hold the packing sleeve in place. This prevents the bolts from wearing the corners away (due to the jarring of the drill) and falling out, as is the case where the slots are cored from the outside. The valve is made of tool steel, and as its end spools never cross a port it never freezes up when operated by compressed air under ordinary conditions. Tripods, columns, hose-couplings and various other accessories are described and listed, and some space is devoted to suggestions for the proper handling of rock drills and mining machinery.

FIREPROOF ASPHALT ROOFING.—Stowell Mfg. Co., 217 Culver Avenue, Jersey City, N. J. Paper; 5½ x 8 ins.; 32 pages; illustrated.

This catalog describes the ten varieties of surfaced roofings and saturated roofing felts manufactured by the company. In their preparation the best quality of fibrous pure wool felt is saturated with Trinidad Lake asphalt and heavily coated with the same material of a stiffer consistency, into which is firmly imbedded a dense surfacing of crushed granite, feldspar, ground asbestos fiber, cork, gravel, sand or ground mica and slate, according to the work for which it is intended. Thus, the crushed granite coating affords a rough, impregnable surface capable of protection against the severest conditions imposed on manufactories, furnaces, foundries, railroad buildings, etc., while the cork roofing serves as a lightweight roof of great durability, furnishing satisfactory protection against the weather and at the same time acting as heat insulation for the building. The respective advantages of the several kinds are set forth in this catalog, and directions are given for laying. Samples will be sent to those interested upon application, together with additional particulars and suggestions as to the best grade to use for any particular purpose.

FUEL GAS FURNACES.—American Gas Furnace Co., 24 John Street, New York City. Illustrated Catalog, 7th Edition. Paper; 8 x 5½ ins.; 212 pages.

This catalog describes the various sizes of the American oil-gas machine, a generator which converts the total of any given quantity of naphtha into perfect fuel gas by an automatic process; the positive pressure blowers for furnishing the air blast required by the generators and gas-blast furnaces for the performance of all mechanical heating processes, such as annealing, assaying, case-hardening, enameling, forging, japanning, melting, rivet heating, tempering, etc. The generators are

regularly made in sizes for converting from 5 to 50 gallons of naphtha into fuel gas per hour—larger sizes to order. Each gallon of naphtha is said to produce a volume of fuel gas equivalent in heating power to 200 cu. ft. of standard city illuminating gas.

"CARBONKOTE" METAL PRESERVATIVE PAINTS.—Nubian Paint & Varnish Co., New York. Paper; 6 x 9 ins.; 16 pages.

The protective effects of carbon lampblack as a water repellent are well known. It is not affected by active chemicals, is electrically passive, non-corrosive and less affected by heat or cold than any other pigment. Lampblack, with other carbons, linseed oil and Chinese wood oil, go to make up the several grades of "Carbonkote," which are compounded for use as metal preservatives, enamels for surfaces subjected to heat, acid resisting coatings for pipes, flues, etc., waterproofing paint for submerged metal surfaces, damp-proof paint for use in breweries, cold storage warehouses, etc. The specific qualities of these various grades are described in this catalog, together with those of "Carbonkote" cement, which is used on bridges subjected to locomotive blasts. A specification for painting structural steel is also included.

GRAPHITE PAINTS.—Detroit Graphite Mfg. Co., Detroit, Mich. Paper; 6 x 9 ins.; 196 pages; illustrated.

This pamphlet shows, by means of half-tone illustrations of buildings, bridges and other steel structures, the extent to which the graphite protective paints manufactured by this company have already been used. The pigment used in these paints is amorphous graphite, obtained from an ore mined in Northern Michigan. This, with other ingredients, is incorporated with linseed oil into a homogeneous substance which has been found to be remarkably successful as a coating for preserving structural metal work from corrosion under extremely severe conditions and for long periods of time.

HOISTING BUCKETS, COAL AND ORE HANDLING MACHINERY, ETC.—G. L. Stuebner Iron Works, 12th Street and Vernon Avenue, Long Island City, N. Y. Catalog No. 555. Paper; 6½ x 9¼ ins.; 156 pages, illustrated.

This is a general catalog of machinery for handling heavy or bulky materials, and comprises descriptions and price-lists of coal-handling machinery; self-dumping and self-righting coal and ore buckets; side, end and bottom dumping cars; track with curves, switches and turntables for industrial railways; valves and screens for coal pockets, coal chutes, charging cars, etc. A recent addition to this line is the "Excelsior" bottom dumping bucket, having a tilting bottom dumping device, by means of which its contents are deposited in a circular pile without scattering any portion of the charge. This bucket is strongly built and its durability combined with quick and clean discharge, has been instrumental in creating a demand that has taxed the plant to its capacity during the past year.

ELECTRIC ROCK DRILLS.—Box Electric Drill Co., 115 Broadway, New York City. Bulletin No. 201. Paper; 6 x 9 ins.; 8 pages; illustrated.

The economy of operating a rock drill actuated by an electric motor over one in which compressed air is used is well known, but one-seventh of the power required for the latter being needed to drive an electric drill of the same size. The severe conditions of rock work, however, have in the past entailed such large expenses for repairs that the economy of this type has been more than neutralized by them. Recent improvements in the Box drill are claimed by the makers to have eliminated certain unsatisfactory features which rendered former types unduly expensive in upkeep, so that it now can be said to surpass any similar device in the matters of efficiency and low cost of maintenance. Two sizes are listed, the smaller requiring 1 HP. to operate and drilling holes from ⅞ to 1½ ins. in diameter, and the larger, requiring 2 HP. for drilling 1⅝ to 2⅝-in. holes.

RIGID TURRET LATHE.—Niles-Bement-Pond Co., New York. Paper; 9 x 6 ins.; pp. 44; illustrated.

This catalogue describes the Pond rigid turret lathe, which is designed for producing work ordinarily done on large engine lathes. On such work as gear blanks, fly wheels, gas engine cylinders, pipe flanges, motor field frames, pulleys, armature spiders, engine valve bonnets, eccentrics, piston heads, globe valves, etc., it is claimed that its use results in an increased production of 50 to 150% over that yielded by ordinary engine lathes. It is also adapted for heavy bar work, such as wrist pins, projectiles, etc. Two sizes, 21-in. and 28-in., are regularly built.

STANDARDIZED ROLLER-BEARING BUSHINGS.—Hyatt Roller Bearing Co., Newark, N. J. Bulletin No. 31. Paper; 6 x 9 ins.; 24 pages illustrated.

The Hyatt flexible roller bearings have been on the market for ten or more years and their adaptability to the requirements of machine constructors and mill engineers has brought them into extended use. The manufacturers have just completed arrangements for supplying standard bushings covering a wide range of speeds and loads at prices which were hitherto impossible except to customers ordering in large quantities. This bulletin lists some 300 sizes for shafts varying from 1 in. to 3 ins. in diameter, and by even inches in length. Each size has a capacity in pound-revolutions, by means of which its safe load at any desired speed may be determined (within its range of speed) and its safe speed for any given load not exceeding the maximum.

FENCING, RAILINGS AND ENTRANCE GATES.—F. E. Carpenter Co., 7-9 Warren Street, New York City. Catalogue No. 79. Paper; 7 x 9 ins.; 56 pages; illustrated.

This catalog describes the line of manufactures of the company, embracing fencing for parks, cemeteries, private estates, game preserves, race tracks, factories, public buildings, tennis court enclosures, etc. The company also manufactures ornamental iron work for buildings, office railings and other enclosures of wire and iron, and will either figure from architects' designs for this class of work, or furnish original designs, as desired.

DIESEL OIL ENGINE.—American Diesel Engine Co., 11 Broadway, New York City. Paper; 10 x 8 ins.; 72 pages; illustrated.

This catalog describes a heat engine operating on crude petroleum oil, which is stated to have double the economy of the best triple-expansion steam engine, and 50% greater economy than the most efficient gas engine. In this engine air is drawn into the cylinder during one stroke, and compressed on the return stroke to a pressure of 500 lbs. per sq. in. Oil and compressed air at a pressure of 800 lbs. per sq. in. are then injected during about one-tenth of the third stroke. The air compressed to 500 lbs. pressure on the second stroke is practically red hot and ignites the injected oil vapor which expands and produces the power. The burnt gases are exhausted on the fourth stroke. The compressed air is furnished by a separate two-stage compressor. Sizes are made from 12 to 450 HP., and a 750-HP. unit is now under construction. The results of numerous tests of engines of various sizes using different grades of oil are given.

MECHANICAL STOKERS.—Lenher Engineering Co., 39 Cortlandt Street, New York City. Paper; 10 x 7 ins.; 28 pages; illustrated.

This catalog describes the construction and operation of the Taylor gravity under-feed stoker, which is claimed to embody all of the advantages possessed by both the over-feed and under-feed types, without their disadvantages, and in addition to accomplish the following results: Proportioning of the air and coal so that the ratio remains constant at all rates of combustion; operation at one-half the rating at which any other stoker now made operates when burning the same amount of coal per boiler per hour; the burning of double the amount of coal per boiler per hour burned by any other stoker; and operation absolutely without the production of smoke, even when forced.

INTERCHANGEABLE STEEL MOLDS FOR CONCRETE HOUSE CONSTRUCTION.—The American Monolith Co., 15 Whitehall Street, New York City. Paper; 4¾ x 8 ins.; 32 pages; illustrated.

This pamphlet gives particulars concerning a number of patented devices for use in the molding of concrete houses, which include interchangeable molds for entire houses constructed on the unit plan, of sheet steel, which can be put up in a few hours, including the assembling of the steel reinforcing rods, allowing the whole shell of the house to be poured, a story at a time; a special machine for automatically mixing the concrete; and a conveyor which carries the mixed concrete automatically into the molds in an expeditious manner and at a governable speed. Territorial rights to use these devices are being granted by the company.

MINERAL WOOL.—United States Mineral Wool Co., 140 Cedar Street, New York City. Paper; 5¼ x 7 ins.; 24 pages; illustrated.

This pamphlet describes the architectural uses of mineral wool, a soft, pliant and inelastic fibrous substance manufactured from scoria and certain rocks when in a molten condition. It is stated to be superior to any other material as a non-conductor of heat, and for this reason is widely used in the lining of

the walls of detached frame houses between the studding, making a warmer dwelling in winter and a cooler one in the summer months. It is also used for wrapping water pipes to protect them against freezing, and in partitions and floors of buildings for deadening sound. As it is non-combustible, its use as a protection against fire is of great value when properly applied. Details of its use and testimonials from those who have employed it for various purposes are given.

HOISTING DRUM.—The Hayward Company, 97-103 Cedar Street, New York City. Paper; 5½ x 8¼ ins.; 16 pages; illustrated.

This circular describes the "Two-in-One" hoisting drum manufactured by this company, which, as its name implies, consists of two drums mounted on the same bed-plate, and acting as one drum. By its use a single-drum engine can be made to operate a double-chain automatic bucket, or a double-drum engine to operate a double-chain automatic bucket and raise or lower the boom at the same time. It can be used on dredges, excavators, guy and stiff-leg derricks, locomotive cranes; in fact, on almost every style of machine capable of operating an automatic bucket. The cost is said to be considerably less than that of an additional drum.

PLANK HOLDERS FOR CONCRETE FORMS.—Thomas C. Farrell, Washington, N. J. Paper; 4½ x 8 ins.; 40 pages; illustrated.

This catalog describes Farrell's patent malleable iron plank holders for joining and clamping the retaining planks of flat surfaces (at all angles), thus forming a movable concrete builders' mould suitable for use in all kinds of plain or reinforced-concrete monolithic construction. Illustrations are given showing its use in the walls and columns of buildings, retaining walls, fence posts, chimneys, tanks, bins and other curved work, buttresses, etc. The devices are easily applied and their use, according to the manufacturer, will result in much saving of time and money in concrete construction.

THERMIT IN REPAIR WORK.—Goldschmidt Thermit Co., 90 West St., New York. Flexible cloth; 5 x 7 ins.; 32 pages; illustrated.

Thermit is a mixture of finely divided aluminum and iron oxide. When ignited in one spot, the combustion so started continues throughout the entire mass and produces superheated liquid steel of so high a temperature (5400° F.) that when it is poured around broken parts of machinery which it is desired to unite, it dissolves the metal with which it comes in contact and amalgamates with it to form a single homogeneous mass when cooled. This pamphlet gives explicit instructions for the use of Thermit in repairing locomotive frames and drivers, connecting rods, electric motor cases, flaws in castings, etc. A price-list of Thermit, the ignition powder used, wax, fire brick molds, and crucibles is appended.

ENGINEERING DESIGN AND SUPERVISION.—Frank Sutton, E. E., Consulting Engineer, 91-93 Wall Street, New York City. Booklet. Paper; 3½ x 6 ins.; 12 pages.

In this booklet is given an extensive list of engineering work designed and supervised by Mr. Sutton during the past few years. This list covers a wide range, embracing electric lighting, power and transmission work; steam power plants; mechanical equipment of buildings; sanitary and sewage disposal work; water supply; sprinkler and fire protection systems; mill construction, etc. Mr. Sutton also undertakes the making of examinations and reports on plants with suggestions for improving and bringing them up to date, as well as the furnishing of estimates of the cost of complete factory buildings, with their equipments.

LIQUID ASPHALT—DUSTLESS ROADWAYS.—Indian Refining Co., 115 Broadway, New York; folder; 4 x 10 ins.; 10 pages; illustrated.

This circular describes a manufactured product containing 75% asphalt in solution, absolutely free from paraffine and sulphur, and without the odor and other objectionable features of crude oil. When applied to properly prepared and crowned roadways Liquid Asphalt is said to provide a smooth, plastic wearing surface which protects the body of the road from the destructive effects of heavy rains and automobile traffic, provides a surface upon which the wheels will not skid, and thereby renders the use of chain tires unnecessary. A saving of at least 50% of the cost of maintenance can consequently be effected by its use. The company has a large equipment of special machinery and is prepared to make contracts for the treating of streets and roadways.

THE

TECHNICAL PRESS INDEX

220 BROADWAY, NEW YORK

This Index is intended to cover the field of technical literature in a manner that will make it of the greatest use to the greatest number—that is, it will endeavor to list all the articles and comment of technical value appearing in current periodicals. Its arrangement has been made with the view to its adaptability for a card-index, which engineers, architects and other technical men are gradually coming to consider as an indispensable adjunct of their offices.

Each item gives:

1. Full title and author.
2. Name and date of publication.
3. An estimate of length of article.
4. A short descriptive note regarding the scope of the article—where considered necessary.
5. Price at which we can supply current articles.

The Publishers do not carry copies of any of these articles in stock, but, if desired, will supply copies of the periodical containing the article at the prices mentioned. Any premium asked for out-of-date copies must be added to this price.

The principal journals in the various fields of technical work are shown in the accompanying list, and easily understood abbreviations of these names are used in the Index.

The Editor cordially invites criticisms and suggestions whereby the value and usefulness of the Index can be extended.

In order to comply with the many suggestions and requests of readers who desire to make practical use of this index, it is printed on one side of the sheet only, to permit the clipping of any desired items.

LIST OF PERIODICALS INDEXED

JOURNALS, PROCEEDINGS AND TRANSACTIONS OF AMERICAN TECHNICAL SOCIETIES

Journal Am. Foundrymen's Assn.
Journal Assoc. Engineering Societies.
Journal Eng. Soc. of Western Pa.
Journal Franklin Institute.
Journal West. Society of Engineers.
Proceedings Am. Soc. C. E.
Proceedings Am. Soc. M. E.
Proceedings Can. Soc. C. E.
Proceedings Engineers' Club, Philadelphia.
Proceedings New York R. R. Club.
Proceedings Pacific Coast Ry. Club.
Proceedings St. Louis Ry. Club.
Proceedings U. S. Naval Institute.
Transactions Am. Inst. Electrical Engineers.
Transactions Am. Inst. Mining Engineers.

(Continued on second page following.)

TECHNICAL PERIODICALS

An inch card under this heading costs $2.50 a mon n

American Builders Review

A Journal Devoted to the Architects, Contractors, Engineers and Builders of the Pacific Coast.

$5.00 per annum in the U. S.—Other Countries, $6.00. Single copies, 50 cents.

643 Stevenson St., SAN FRANCISCO, CAL.

The Canadian Municipal Journal

Official Organ of the Dominion and Provincial Unions of Municipalities.

Reaches the officers of EVERY municipality in Canada. Monthly, one dollar per year; ten cents per copy.

Room 29, Alliance Building, MONTREAL, CANADA.

Compressed Air

Monthly, devoted to the theory and practice of compressed air, pneumatic tools, air compressor design, air lift pumping, tunneling, rock excavation, etc.

10c. per copy. $1.00 per year.

Published by THE COMPRESSED AIR MAGAZINE CO., Bowling Green Bldg., NEW YORK CITY.

Electric Railway Review

Best edited, most up-to-date and rapidly-growing journal in the traction field. Published every Saturday. Domestic, $2.00; Canada, $3.50; other foreign countries, $5.00; single copies, 10 cents.

THE WILSON COMPANY,
160 Harrison St., Chicago. 150 Nassau St., New York.
1529 Williamson Bldg., Cleveland, O.

Engineering-Contracting

A Weekly Journal for Civil Engineers and Contractors; with which is incorporated ENGINEERING WORLD and CONTRACT NEWS.

Established 1891—Every Wednesday—$2 a Year.

Single copies 10 cents.

353 Dearborn St., CHICAGO, ILL.

Engineering News

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Weekly, $5.00 per year; single copies, 15 cents. Published every Thursday by THE ENGINEERING NEWS PUBLISHING CO., 220 Broadway, NEW YORK.

The Industrial Magazine

A Monthly Magazine on Industrial Engineering for Engineers and Contractors.

Single copies 20 cents. One year $2.00.

21 Park Row, NEW YORK.

The Iron Age

A Journal of the Iron, Steel, Metal, Machinery and Hardware Trades.

Subscription Price, $5.00 per year in the United States and Mexico; $7.50 in all other countries. Single copies 15 cents.

DAVID WILLIAMS CO., 14-16 Park Place, NEW YORK.

Mining Science

A consolidation of Ores and Metals and Mining Reporter

A Weekly Journal Devoted to Mining, Metallurgy and Engineering.

$3.00 a year. 10 cents a copy.

DENVER, COLO.

Progressive Age

Treats of Gas and its application to domestic and industrial operations. Subscription $3. Specimen copy, 15 cents.

280 Broadway, NEW YORK.

The Railway Age

Leader and acknowledged authority in all steam railway matters. Published every Friday; over 2,000 pages a year. Domestic, $4.00; Canada, $5.50; other foreign countries, $6.00; single copies, 10 cents.

THE WILSON COMPANY,
160 Harrison St., Chicago. 150 Nassau St., New York.
1529 Williamson Bldg., Cleveland, O.

Roadmaster and Foreman

Established 1885.

For Roadmasters and Foremen, Engineers and Superintendents of Maintenance of Way, Superintendents and Foremen of Bridges and Buildings.

Monthly, $1.00 per year; single copies, 10 cents.

353 Dearborn St., CHICAGO, ILL.

Publishers will find it to their advantage to have a one-inch card on this page, opposite the list of Periodicals Indexed. . . . .

ASK US ABOUT IT

It Will Be Mutually Beneficial to Say Where You Saw the Advertisement.

AMERICAN AND CANADIAN PERIODICALS

Acetylene Journal.
American Architect and Building News.
American Artisan.
American Builders' Review.—See Adv. opposite.
American Carpenter & Builder.
American Engineer and R. R. Journal.
American Exporter.
American Gas Light Journal.
American Industries.
American Inventor.
American Journal of Science.
American Machinist.
American Shipbuilder.
Architect & Engineer of California.
Architectural Art.
Architectural Record.
Architectural Review.
Architects' and Builders' Mag.
Architecture.
Automobile.
Boiler Maker.
Brass World.
Brick.
Bulletin Am. Iron & Steel Assn.
Bulletin of Dept. of Labor.
Bulletin Univ. of Kansas.
Bulletin Univ. of Wisconsin.
California Journal of Technology.
Canadian Architect and Builder.
Canadian Cement & Concrete Review.
Canadian Electrical News.
Canadian Engineer.
Canadian Machinery & Manufacturing News.
Canadian Manufacturer.
Canadian Mining Journal.
Canadian Municipal Journal.—See Adv. opposite.
Carpentry and Building.
Cassier's Magazine.
Castings.
Cement.
Cement Age.
Cement and Engineering News.
Cement Era.
Central Station.
Chemical Engineer.
Cold Storage and Ice Trade Journal.
Commercial America.
Compressed Air.—See Adv. opposite.
Concrete.
Concrete Age.
Concrete Engineering.
Contractor.
Cornell Civil Engineer.
Daily Consular and Trade Reports.
Domestic Engineering.
Economic Geology.
Electrical Age.
Electrical Review.
Electric Journal.
Electric Railway Review.—See Adv. opposite.
Electrical World.
Electric Traction Weekly.
Electrochemical and Metallurgical Industry.
Engineering-Contracting.—See Adv. opposite.
Engineering and Mining Journal.
Engineering Magazine.
Engineering News.—See Adv. opposite.
Engineering Record.
Factory.
Far Eastern Review.
Fire and Water Engineering.
Forestry and Irrigation.
Foundry.
Gas Engine.
Gas Power.
Glass and Pottery World.
Hardware.
Heating and Ventilating Magazine.
Horseless Age.
Ice and Refrigeration.
Illuminating Engineer.
Implement Age.
Industrial Magazine.—See Adv. opposite.
Industrial World.
Inland Architect.
Insurance Engineering.
International Marine Engineering.
Iron Age.—See Adv. opposite.
Iron Trade Review.
Irrigation Age.
Journal of Electricity, Power and Gas.
Journal of U. S. Artillery.
Journal of Worcester Polytechnic Institute
Machinery.
Marine Review.
Metal Industry.
Metal Worker, Plumber and Steam Fitter.
Mines and Minerals.
Mines and Mining.
Mining and Scientific Press.
Mining Science.
Mining World.
Modern Machinery.
Moody's Magazine.
Motor.
Motor Age.
Motor Boat.
Motor Car.
Municipal Engineering.
Municipal Journal and Engineer.
Paper Trade Journal.
Plumber's Trade Journal.
Popular Mechanics.
Popular Science Monthly.
Power and The Engineer.
Power and Transmission.
Power Wagon.
Printers' Ink.
Profitable Advertising.
Progressive Age.—See Adv. opposite.
Railroad Gazette.
Railway Age.—See Adv. opposite.
Railway and Engineering Review.
Railway and Locomotive Engineering.
Railway and Marine World.
Railway Engineering.
Railway Master Mechanic.
Roadmaster and Foreman.—See Adv. opposite.
Rock Products.
Rose Technic.
Scientific American.
Scientific American Supplement.
Selling Magazine.
Sibley Journal of Engineering.
Southern Machinery.
Stevens Institute Indicator.
Stone.
Street Railway Journal.

Technical World Magazine.
Technology Quarterly.
Textile Manufacturer's Journal.
Tradesman.
Waterproofing and Fireproofing.
Western Electrician.
Wood Craft.
Wood Worker.

PRINCIPAL BRITISH PERIODICALS

Agricultural Chronicle. (m.) London.
Architect. (w.) London.
Architects' Magazine. (m.) London.
Architectural Review. (m.) London.
Autocar. (m.) London.
Automobile Journal. (m.) London.
Automotor Journal. (w.) London.
Board of Trade Journal. (w.) London.
British Architect. (m.) London.
British Clay Worker. (m.) London.
British Trade Review. (m.) London.
Builder. (w.) London.
Building Industries. (w.) Glasgow.
Civil Engineering. (w.) London.
Cold Storage. (m.) London.
Colliery Guardian. (w.) London.
Commercial Motor. (w.) London.
Concrete & Constr. Engg. (b-m.) London.
Contract Journal. (w.) London.
Electrical Engineer. (w.) London.
Electrical Engineering. (w.) London.
Electrical Magazine. (m.) London.
Electrical Progress. (m.) London.
Electrical Review. (w.) London.
Electrician. (w.) London.
Electricity. (w.) London.
Engineer. (w.) London.
Engineering. (w.) London.
Engineering Review. (m.) London.
Engineering Times. (w.) London.
Engineering World. (w.) London.
Engineers' Gazette. (m.) London.
English Mechanic. (w.) London.
Gas and Oil Power. (m.) London.
Gas Engineers' Magazine. (m.) London.
Hardware Magazine. (m.) London.
Implement and Machinery Rev. (m.) London.
Iron and Coal Trades Review. (w.) London.
Iron and Steel Trades Journal. (w.) London.
Ironmonger. (w.) London.
Ironmongers' Chronicle. (w.) London.
Journal of Gas Lighting. (w.) London.
Journal of Society of Arts. (w.) London.
Locomotive Magazine. (m.) London.
Marine Engineer. (m.) London.
Mariner. (m.) London.
Mechanical Engineer. (w.) Manchester.
Mechanical World. (w.) Manchester.
Mining Engineering. (m.) London.
Mining Journal. (w.) London.
Mining World. (w.) London.
Motor. (w.) London.
Motor Boat. (w.) London.
Motor Car Journal. (w.) London.
Motoring Illustrated. (m.) London.
Municipal Journal. (w.) London.
Nature. (w.) London.
Oil Trades Gazette. (m.) London.
Page's Weekly. (w.) London.
Paper Maker. (m.) London.
Paper Making. (m.) London.
Petroleum World. (m.) London.
Practical Engineer. (w.) London.
Public Works. (q.) London.
Quarry. (m.) London.
Railway Engineer. (m.) London.
Railway Gazette. (w.) London.
Railway Magazine. (m.) London.
Railway Times. (w.) London.
Science Abstracts. (m.) London.
Sells' Commercial Advertiser. (w.) London.
Surveyor. (w.) London.
Textile Journal. (m.) London
Timber Trades Journal. (m.) London.
Times Engineering Supplement. (w.) London.
Tramway and Railway World. (m.) London.
Water. (m.) London.

PRINCIPAL FRENCH, GERMAN AND OTHER FOREIGN PERIODICALS

Annales des Ponts et Chaussées. (m.) Paris.
Beton und Eisen. (q.) Vienna.
Betonzeitung. (s-m.) Halle a/S.
Cemento. (m.) Milan.
Comptes Rendus de l'Acad. des Sciences. (w.) Paris.
Deutsche Bauzeitung. (b-w.) Berlin.
Dingler's Polytechnic Journal. (w.) Berlin.
Eisenbahntechnische Zeitschr. (b-m.) Berlin.
Electricien. (w.) Paris.
Elektrische Kraftbetriebe und Bahnen. (w.) Berlin.
Elektrochemische Zeitschrift. (m.) Berlin.
Elektrotechnik und Maschinenbau. (w.) Vienna.
Elektrotechnische Zeitschrift. (w.) Berlin.
Elettricità. (w.) Milan.
Génie Civil. (w.) Paris.
Gesundheits-Ingenieur. (s-m.) Munich.
Industrie Electrique. (s-m.) Paris.
Ingenieria. (s-m.) Buenos Aires.
Ingenieur. (w.) Hague.
Journal f. Gasbeleuchtung. (w.) Berlin.
Métallurgie. (w.) Paris.
Minero Mexicano. (w.) Mexico.
Mois Scientifique. (m.) Paris.
Organ f. d. Fortschritte des Eisenbahnwesens. (m.) Wiesbaden.
Revista d. Obras Pub. (w.) Madrid.
Revista Tech. Indus. (m.) Barcelona.
Revue de Mécanique. (m.) Paris.
Revue Gén. des Chemins de Fer. (m.) Paris.
Revue Gén. des Sciences. (w.) Paris.
Revue Industrielle. (w.) Paris
Revue Technique. (b-m.) Paris.
Revista Marittima. (m.) Rome.
Schiffbau. (s-m.) Berlin.
Schweizerische Bauzeitung. (w.) Zurich.
Stahl und Eisen. (w.) Düsseldorf.
Technique Sanitaire. (m.) Paris.
Zeitschrift für Bauwesen. (q.) Berlin.
Zeitschrift f. d. Gesamte Turbinenwesen. (w.) Munich.
Zeitschrift d. Oest. Ing. und Arch. Ver. (w.) Vienna.
Zeitschrift d. Ver Deutscher Ing. (w.) Berlin.
Zeitschrift für Elektrochemie. (w.) Halle a/S.
Zentralblatt d. Bauverwaltung. (s-w.) Berlin.

Index to Articles begins on Second Page Following.

Resembling Rubber, It Is A Preservative

¶ In order to properly and scientifically protect a surface from corrosion, decay or other destructive agent, as in the case of steel, iron, wood or concrete, it is necessary to cover or treat the same with a substance or liquid which is absolutely weather, water and acid proof. The protective qualities of Carbon Lampblack against water, oxidation or acids place it in the foremost rank as a pigment. It is greasy and in a measure elastic. **This,** combined with other carbons, forms the pigment for several grades of

CARBONKOTE

¶ In the manufacture of **Nubian Carbonkote,** Linseed Oil and Chinese or Tong Oil are chemically combined. The combination is more expensive than Linseed, but it produces a quality of paint unequaled. One of its peculiarities is in its drying simultaneously throughout the coat. Linseed dries with a thin skin on the surface, and to this fault may be laid many failures of paint.

¶ Chinese Linseed Varnish is particularly adapted as a vehicle for paint exposed to atmospheric influences, on account of hardness, solidity, quick drying, elasticity and water repellent properties. The addition of Linseed in the proportions employed in **Carbonkote** imparts greater adhesive properties and does not destroy its peculiarity of drying uniformly throughout.

¶ It costs you nothing to send for information on **Carbonkote.** We have just received from the printers our new literature, which explains in detail our paint and also gives important information on the preparation of a surface to receive paint, so that the best possible results may be obtained.

Send for It

NUBIAN PAINT & VARNISH CO.

40 Park Row, NEW YORK

It Will Be Mutually Beneficial to Say Where You Saw the Advertisement.

INDEX TO ARTICLES

ARCHITECTURE.

For Steel and Reinforced Concrete Building Construction, Foundations, Masonry, etc., see "Engineering Construction and Materials" under CIVIL ENGINEERING; for Heating and Ventilation, see subdivision similarly entitled under MECHANICAL ENGINEERING; for Electric Lighting, see "Lighting" under ELECTRICAL ENGINEERING; for Elevators, see "Hoisting and Handling Machinery" under MECHANICAL ENGINEERING; for Plumbing and Sanitation, see "Sewerage" under MUNICIPAL ENGINEERING.

Business Structures.

Some Business Buildings in St. Louis. Wm. Herbert. Arch. Rec.—May, 08. 3 figs. 2200 w. 40c.

Cincinnati.

The Building of Cincinnati. Montgomery Schuyler. Arch. Rec.—May, 08. 31 figs. 6000 w. 40c.

College Buildings.

The College of the City of New York. Am. Arch.—May 13, 08. 22 figs. 5100 w. 20c.

Ecole des Beaux-Arts.

The Ecole des Beaux-Arts: What Its Architectural Teaching Means. Paul Cret. Arch. Rec.—May, 08. 3800 w. 40c.

Warehouses.

Some Recent Warehouses. Russell Sturgis. Arch. Rec.—May, 08. 10 figs. 3400 w. 40c.

AUTOMOBILES AND AERIAL NAVIGATION

Ball Bearings.

Automobile Hub Ball Bearings. Henry Hess. Automobile—Mar. 5, 08. 7 figs. 2000 w. 20c. Paper read before the Society of Automobile Engineers.

Commercial Motor Vehicles.

Commercial Motor Vehicles.—I. Engg—May 1, 08. .5800 w. 40c. Abstract of a report of tests conducted by the Royal Automobile Club, giving the chief results of the competitive trials.

Forgings for Autos.

About Forgings for Automobile Work. Richard W. Fink. Gas Engine—May, 08. 1100 w. 20c. Paper read before the Society of Automobile Engineers at Boston, Mar. 10-11, 08.

Helicopter.

The Cornu Helicopter. Sc. Am.—May 16, 08. 4 figs. 2100 w. 20c. Describes the experiments of M. Paul Cornu on a helicopter, consisting of two relatively large propellers revolved in opposite directions and arranged to blow downward upon two small planes set at an angle from the vertical.

Motor Traffic as Affecting Municipalities.

Motor Traffic as It Affects Municipalities.—I. A. E. Jackson. Surveyor—April 10, 08. 4200 w. 40c. Paper read before the Manchester Association of Students of the Institution of Civil Engineers.

Six-Cylinder Automobile, Advantages of.

The Six-Cylinder Automobile. Herbert L. Towle. Cass Mag—May, 08. 16 figs. 2,500 w. 40c. Sets forth the advantages a 6-cylinder motor possesses over motors with a lesser number.

Tractor.

The Caterpillar Tractor. Sc Am—May 16, 08. 4 figs. 1,400 w. 20c. Describes a new type of tractor having a series of feet disposed along the periphery of two heavy side chains passing over fore and aft wheels. As this chain revolves the feet are successively brought into contact with the ground thereby impelling the machine forward or backward.

CIVIL ENGINEERING

BRIDGES.

Bascule Bridge.

Bascule Bridge of the Rall Type at Peoria, Ill. Eng Rec—May 9, 08. 8 figs. 2,200 w. 20c. Describes a deck structure with two movable platforms each 12 ft. wide and 83½ ft. long, which, when the bridge is in service, form cantilevers located together in the center of the channel. Each platform has two full-length plate girders forming cantilevers fulcrumed and pivoted on the main piers 17 ft. 5 ins. from the extremities of the anchor arms.

Bridge Construction in the U. S.

Bridge Construction in the United States. (Concluded.) F. Dircksen. Z V D I—Apr. 11, 08. 8 figs. 5,000 w. 60c. Discusses erecting cranes, replacements and viaduct construction.

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Concrete Ry. Bridge.

The Sangamon River Bridge. A. O. Cunningham. Eng Rec—May 16, 08. 1 fig. 700 w. 20c. Describes a new double-track concrete bridge lately constructed by the Wabash R. R. over the Sangamon River, just east of Decatur, Ill.

Erection.

Erection of Bridges. Ry Engr (Lond)—May, 08. 5 figs. 2,500 w. 40c. X.—River Dal Railway Bridge in Sweden and the Paderno Viaduct, Italy.

Methods of Erecting a Steel Arch Bridge. Eng Contr—May 6, 08. 2 figs. 2700 w. 20c. From a paper by L. D. Rights entitled "The Erection of the Bellows Falls Arch Bridge," presented before the Am. Soc. C. E. on Apr. 1, 08.

The Erection of the Tonawanda, Pa., Bridge. Eng Rec—May 2, 08. 3 figs. 3500 w. 20c. Describes the placing of the deck-girder spans by means of a Pratt truss traveler.

Flooring vs. Stringers.

Flooring vs. Stringers. Louis Ross. Eng News—Apr. 23, 08. 4 figs. 6,300 w. 20c. Gives formulas, with derivation, showing the distribution of stresses between the stringers and flooring of highway bridges.

Latticing of Columns.

The Latticing Requirements of Built-up Steel Columns. (Cont.) F. Von Emperger. Beton u Eisen—Apr. 1, 08. 3 figs. 1,500 w. Apr. 22, 08. 2 figs. 1,000. Each $1.

Manhattan Bridge.

Methods and Plant Used in Placing Concrete and Masonry for Brooklyn Anchorage for Manhattan Bridge. Gustave Kaufman. Engg-Contr—March 18, 08. 2 figs. 4,100 w. 20c. Abstract of a paper read before the Brooklyn Engineers' Club. May 10, 1906.

The Towers of the Manhattan Bridge over the East River at New York City. Eng News—Apr. 16, 08. 7 figs. 3,400 w. 20c.

Masonry Arch Design.

A Working Method for Masonry Arch Design. William T. Lyle. Eng Rec—May 2, 08. 2 figs. 1,500 w. 20c. Gives a concise and practical method for determining the pressure on the extrados in amount and direction, and the true location of the line of pressure in the arch ring.

Pontoon Drawbridges.

Pontoon or Floating Drawbridges. Eng News—Apr. 30, 08. 10 figs. 6,200 w. 20c. Describes and illustrates a considerable number of such structures now in use.

Quebec Bridge, Stresses in.

A Critical Discussion of Certain Parts of the Specifications. Eng News—Apr. 30, 08. 3,900 w. 20c. Appendix 18, to the report of the Quebec Bridge Commission.

A Discussion of the Theory of Built-up Compression Members. Eng News—Apr. 30, 08. 8,100 w. 20c. Appendix 16, to the report of the Quebec Bridge Commission.

Appendix 15, Report of Royal Commission on Quebec Bridge. Eng Rec—Apr. 18, 08. 8 figs. 6,300 w. 20c. Describes the various experimental researches that have been made in connection with the building of the Quebec Bridge and during the enquiry.

Tests of Two Compression Chord Models: The Largest Column Tests Ever Made. Eng News—Apr. 23, 08. 7 figs. 8,800 w. 20c. Résumé of Appendix 15 of the Quebec Bridge Commission's Report. One of the two test members was in its main part an exact model of the fatal Chord 9 of the anchor-arm, while the other was similar differing only in being strengthened at those points where the chief weakness of the Quebec Bridge chords is thought to have been located.

The Wreck of the Quebec Bridge and the Stresses in the Bridge. Eng News—Apr. 16, 08. 2 figs. 4,400 w. 20c. A summary of appendices 12 and 14 of the Commission's report, describing the cause of the collapse and the stresses in the bridge.

Typical Compression of Large Cantilever Bridges. Eng News—Apr. 30, 08. 6 figs. 2,300 w. 20c. Appendix 17 to the report of the Quebec Bridge Commission; gives data of typical compression of six large cantilever bridges, the Memphis, Thebes, Monongahela, Blackwell's Island, Forth and Quebec bridges.

Wind Pressure and Deflections. Eng News—Apr. 30, 08. 400 w. 20c. Appendix 19 to the report of the Quebec Bridge Commission.

Riveting.

Calculating Net Section of Riveted Tension Members and Fixing Rivet Stagger. Victor H. Cochrane. Eng News—Apr. 23, 08. 2 figs. 900 w. 20c.

Viaduct.

A German Railway Viaduct of Cantilever Construction with Novel Hinge Detail. Eng News—Apr. 23, 08. 2 figs. 1,100 w. 20c. Describes a single-track deck railway viaduct of unusual design at Westerburg, Germany, on a new branch line of the Prussian State Railways.

Wooden Trestle.

A Large Wooden Trestle at McGill, Nevada. J. L. Dobbins. Eng News—Apr. 16, 08. 3 figs. 1,300 w. 20c. Describes a timber trestle 1,212 ft. long, forming the approach to a large smelter.

EARTHWORK, ROCK EXCAVATION, ETC.

Earthwork Costs.

Comparative Costs of Earthwork. A. P. Davis. Eng Rec—May 16, 08. 5 figs. 5,600 w. 20c. Gives data obtained in the extensive work of the U. S. Reclamation Service.

In Press

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AND THE

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TABLE OF CONTENTS

STRESSES IN TRUSS BRIDGES

Chapter I.—Types of Truss Bridges.
Chapter II.—Loads and Weights of Bridges.
Chapter III.—Methods for the Calculation of Stresses in Framed Structures.
Chapter IV.—Stresses in Beams.
Chapter V.—Stresses in Highway Bridge Trusses.
Chapter VI.—Stresses in Railway Bridge Trusses.
Chapter VII.—Stresses in Portals and Lateral Systems.
Chapter VIII.—Stresses in Pins, Combined and Eccentric Stresses, Stresses in Rollers, Deflection of Trusses, Camber, etc.
Chapter IX.—The Solutions of 24 Problems in the Calculation of Stresses in Bridge Trusses.

THE DESIGN OF HIGHWAY BRIDGES

Chapter X.—The Design of Short Span Steel Bridges.
Chapter XI.—The Design of High Truss Steel Bridges.
Chapter XII.—The Design of Plate Girder Bridges.
Chapter XIII.—The Design of Truss Members.
Chapter XIV.—The Details of Highway Bridge Members.
Chapter XV.—The Design of Abutments and Piers.
Chapter XVI.—Stresses in Masonry Arches.
Chapter XVII.—Design of Masonry Bridges and Culverts.
Chapter XVIII.—The Design of Timber and Combination Bridges.
Chapter XIX.—The Erection of Highway Bridges.
Chapter XX.—Estimates and Cost of Highway Bridges.

HIGHWAY BRIDGE DETAILS

Chapter XXI.—Estimate of the Weight of a 160 ft. Span Steel Pin-Connected Highway Bridge.
Chapter XXII.—Calculation of the Efficiencies of the Members of a 160 ft. Span Steel Pin-Connected Highway Bridge.
Appendix I.—General Specifications for Steel Highway Bridges.

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Hydraulic Grading.

Railroad Grading by Hydraulic Methods on the Chicago, Milwaukee & St. Paul Railway. Eng Rec—May 2, 08. 3 figs. 7,000 w. 20c. Describes grading work involving 1,000,000 cu. yds. of excavation in about half a mile being done by hydraulic mining and sluicing methods on the Pacific coast extension of the C., M. & St. P. Ry., at a point 14 miles west of the summit of the Cascade Mountains in the State of Washington.

Regrading of Seattle, Wash.

Regrading of Seattle, Washington. Eng Rec—May 9, 08. 5 figs. 5,400 w. May 16. 5 figs. 4,000 w. Each 20c. Describes work which has been in progress for several years and has already involved the moving of tremendous quantities of materials and the complete reconstruction of a large portion of the city.

Stump Removal.

Method and Cost of Blasting More Than 3,500 Stumps. Eng-Contr—May 13, 08. 1,000 w. 20c.

ENGINEERING CONSTRUCTION.

Arches to Resist Water Pressure.

The Calculation of Horizontal Circular Arches to Resist Water Pressure. E. Mörsch. Schw Bau—May 2, 08. 3 figs. 1,100 w. 40c. Mathematical article.

Buildings.

Deep Underpinning for a Brick Factory Building. Eng Rec—May 2, 08. 3 figs. 2,400 w. 20c.

Method of Constructing Reinforced Concrete Underpinning for 14-story Building on Line of Washington Street Tunnel, Boston, Mass. Eng-Contr—May 13, 08. 1 fig. 1,700 w. 20c.

Reinforced Concrete Building for Oil-Tank. C. F. Leonard. Prog Age—Apr. 15, 08. 1 fig. 2,200 w. 20c.

Reinforced Concrete Cantilever Girders in the Boyertown Building, Philadelphia. Eng News—Apr. 23, 08. 5 figs. 1,400 w. 20c. Describes a novel application of the cantilever principle in reinforced concrete buildings for the support of walls projecting beyond the foundations.

The Bostwick-Braun Building, Toledo, Ohio. C. A. P. Turner. Eng Rec—May 2, 08. 6 figs. 3,200 w. 20c. Describes construction of an 8-story wholesale hardware store 220 ft. square, which was erected in record time, and with the employment of extremely simple centering.

The Construction of the New Municipal Theater at Kiel—I. O. Leitholf. Z V D I—Apr. 18, 08. 19 figs. 6,000 w. May 2. 9 figs. 6,000 w. Each 60c.

The Limitation of Height and Area of Buildings in New York. Ernest Flagg. Am Arch—Apr. 15, 08. 3,100 w. 20c.

The Phelan Building, San Francisco, Floor Construction. Eng Rec—May 2, 08. 9 figs. 2,400 w. 20c.

The Reinforced Concrete Stadium at the Franco-British Exhibition, 1908. Conc & Const Eng—May, 08. 6 figs. 600 w. 40c.

The Ten-Story Reinforced-Concrete Hostetter Building, Pittsburg, Pa. Eng News—May 14, 08. 2 figs. 1,400 w. 20c.

Chimneys.

An Unusual Concrete Chimney. Eng Rec—May 2, 08. 2 figs. 500 w. 20c. Describes an interesting use of reinforced concrete for a peculiar combination of chimney, smoke and spark arrester.

Ferro-Concrete Chimneys. Engg—Apr. 10, 08. 400 w. 40c. Communication from C. Percy Taylor giving table of wider application than that in his article in the Mar. 12 issue of the journal.

Protection of Chimneys against the Influence of Weather. H. C. Nussbaum. Gesund Ingr—Apr. 18, 08. 1,500 w. 60c.

Conduits.

A Wood Pipe Conduit Constructed at Carney's Point, N. J. T. C. Hatton. Mun Jl & Engr—May 6, 08. 4 figs. 1,900 w. 20c.

The Cost of Building Electrical Conduits in Baltimore, Md. Eng-Contr—Apr. 1, 08. 6 figs. 7 tables. 3,300 w. 20c.

Culvert Pipes, Tests of.

Tests of Cast Iron and Reinforced Concrete Culvert Pipe. Prof. Arthur N. Talbot. Eng-Contr—Apr. 22, 08. 8 figs. 4,000 w. Apr. 29. 6 figs. 3,800 w. May 6, 6 figs. 3,700 w. Each 20c. Condensed from a paper read before the Western Society of Engineers, Apr. 15, 08. Discusses the mechanics of pipes and rings subject to external pressure and gives the results of tests on both kinds of pipe.

Cylindrical Retaining Walls.

The Distribution of Stresses in Cylindrical Retaining Walls. H. Reissner. Beton u Eisen—Apr. 22, 08. 2 figs. 4,000 w. $1. Mathematical analysis.

Dams.

An Earth Dam with a Reinforced Concrete Core Wall, at Dixville, N. H. Arthur W. Dudley. Eng Rec—Apr. 25, 08. 1 fig. 1,200 w. 20c.

A Small Concrete Dam. Samuel H. Lea. Eng Rec—May 9, 08. 2 figs. 1,600 w. 20c.

Method and Cost of Lock and Dam Construction by the U. S. Government on the Upper White River, Arkansas. Eng-Contr—May 6, 08. 6 figs. 15,100 w. 20c.

Movable Dams for the Barge Canal. James Cooke Mills. Can Engr—May 1, 08. 3 figs. 1,600 w. 20c.

The Break in the Hauser Lake Dam, Montana. F. L. Sizer. Engr News—Apr. 30, 08. 4 figs. 1,200 w. 20c. Gives details of the failure of the steel dam.

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The Cataract Dam, Sydney, N. S. W. Engg—Apr. 24, 08. 9 figs. 2500 w. 40c. Describes this recently completed structure, which is the largest of its kind in the Southern Hemisphere.

The Concrete Dam of the Lynchburg Water Supply. Eng Rec—May 16, 08. 2 figs. 1,200 w. 20c.

The Design of Buttressed Dams of Reinforced Concrete. R. C. Beardsley. Eng News—Apr. 23, 08. 4 figs. 3,300 w. 20c.

The Marseilles, Ind., Concrete Dam. Dr. J. H. Goodell. Sc Am—Apr. 18, 08. 1,600 w. 20c. Describes the construction of a dam on the Illinois River utilizing the large volume of water from the Drainage Canal, together with the watershed water from the Kankakee and Desplaines Rivers.

Dome, Steel.

A Complicated Steel Dome. Eng News—May 14, 08. 3 figs. 600 w. 20c. Describes a large steel dome constructed for a building in San Francisco.

Poles, Concrete.

Bending Tests of Hollow Reinforced Concrete Poles. F. Schüle. Beton u Eisen—Apr. 1, 08. 2 figs. 700 w. $1.

Reinforced Concrete Construction.

A Hooped Reinforced-Concrete Beam. Eng News—May 7, 08. 1 fig. 1,100 w. 20c. Discusses a recent British design of beam of doubtful utility.

Characteristics of the Chief Systems of Reinforced Concrete Applied to Civil Engineering Works in Great Britain. Conc & Constr Eng—May, 08. 3400 w. 40c. Part II.

Concrete for Construction on the Pacific Coast. H. A. Crafts. Cass Mag—May, 08. 3 figs. 1,300 w. 40c. Describes a pile consisting of a central group of three wooden piles surrounded by a wooden-stave pipe. Reinforcement is introduced in the annular space and rich concrete is then forced in. The wooden pipes being destroyed sooner or later by marine insects, leaves a strong and elastic wooden core protected by concrete.

Manipulation of Forms in Concrete Construction. Cement—Apr., 08. 3,000 w. 40c. Paper delivered before the National Association of Cement Users.

Reinforced Concrete. VIII. Ernest McCullough. Cem Era—May, 08. 1 fig. 5,300 w. 20c. Gives formulas for calculating walls, tanks and footings.

Reinforced-Concrete Brackets Under Skew Sidewalks. C. L. Slocum. Eng News—Apr. 30, 08. 3 figs. 600 w. 20c. Describes construction used in New Haven for supporting sidewalks which overhang the tracks in a cut.

Reinforced Concrete Columns. P. Gillespie and W. C. Sawn. Can Engr—May 1, 08. 3 figs. 6,000 w. 20c. Describes recent experiments conducted in the testing laboratory of the Department of Engineering of Toronto University.

Reinforced Concrete in Reservoir, Aqueduct and Conduit Construction. E. R. Matthews. Conc & Const Engg—May, 08. 6 figs. 1,200 w. 40c. Part II.

Stirrups in Reinforced Concrete Construction. Their Place and Power. W. H. Brown. Jl of Soc Arch (Lond)—May, 08. 6 figs. 1,100 w. 40c.

The Bolting of Metal to Concrete Work. George Rice. Cem Wld—Apr., 08. 11 figs. 1,100 w. 20c. Describes methods that will obviate or prevent the cracking of the walls.

The Effect of the Strength of Joints on the Resistance of Built Blocks. Cement—Apr., 08. 2 figs. 1,600 w. 40c.

The Elastic Curve (Curvature) of Reinforced Concrete Beams. H. Ehrlich. Beton u Eisen—Apr. 1, 08. 3 figs. 1,100 w. $1.

The Influence of Transverse Forces on the Disposition of the Reinforcing in Reinforced Concrete Beams. J. Thieme. Beton u Eisen—Apr. 1, 08. 11 figs. 3,500 w. $1.

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Reinforced Concrete Railway Platform Roof Supported by Central Columns. J. M. Schuster. Beton u Eisen—Apr. 1, 08. 7 figs. 600 w. $1. Describes construction used at the Nuremburg station.

Sewers.

Maximum Permissible Gradient for Sewer Pipes. Th. Heyd. Gesund-Ingr—Apr. 11, 08. 1200 w. 60c.

Phenomena of the Crushing of Sewer Conduits. James H. Hazlehurst. Mun Engg—May, 08. 2100 w. 40c. Extract from a paper before the American Society of Municipal Improvements.

Reinforced Concrete Sewers in Wilmington, Del. Eng Rec—May 9, 08. 1 fig. 1,500 w. 20c.

The Canal Street Tunnel Sewer, New York City. Eng Rec—Apr. 18, 08. 8 figs. 3,000 w. 20c.

Subways and Tunnels.

The Construction of the Market Street Subway, Philadelphia, Pa. Eng Rec—Apr. 25, 08. 6 figs. 3,300 w. 20c.

The East River Tube Connecting New York and Brooklyn. Elec Rev—Apr. 11, 08. 14 figs. 5500 w. 20c. Describes construction of the subaqueous tunnels and the electropneumatic block signaling and interlocking system.

The New Blue Island Avenue Water Tunnel, Chicago. Eng Rec—May 9, 08. 6 figs. 3700 w. 20c. Describes the circular tunnel, having a total length of approximately 2800 ft., being driven in Chicago to form a part of the system of tunnels connecting the intake cribs in Lake Michigan with the pumping stations from which the distributing mains of the municipal water-works are supplied under direct pressure.

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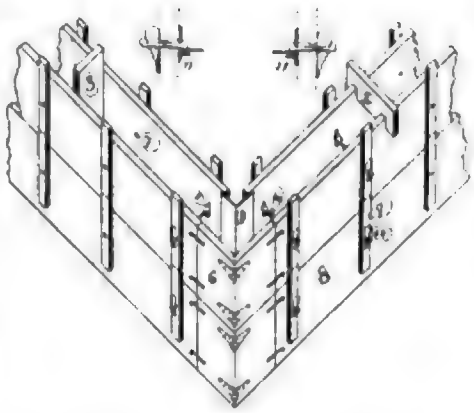

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The Washington Street Tunnel of the Boston Subway System. Eng Rec—May 16, 08. 5 figs. 3400 w. 20c.

Water Mains, Laying of.

Cost of Hauling a Water Main Across Channel at Vancouver, B. C. Eng News—May 14, 08. 3 figs. 2200 w. 20c.

The Method and Costs of Laying a Submerged 12-in. Water Main. J. Causley. Eng-Contr—Apr. 22, 08. 6 figs. 3600 w. 20c. Abstract from a paper read before the Canadian Society of Civil Engineers, Feb. 20, 08.

Waterproofing.

Modern Methods of Waterproofing Reservoirs. Wtrpfg & Fireprfg—Apr., 08. 3 figs. 1000 w. 20c.

Some Suggestions on the Matter of Uniform Specifications for Waterproofing.—I. Myron H. Lewis. Conc—May, 08. 1800 w. 20c.

Waterproofing Concrete. W. Lawrence Gadd. Conc & Const Eng—May, 08. 1300 w. 40c.

Water Tanks, Reinforced-Concrete.

Elevated Reinforced-Concrete Water Tanks in Cuba. Eng News—Apr. 30, 08. 4 figs. 600 w. 20c. Gives half-tones and drawings showing a pair of reinforced concrete water tanks recently built near Havana, Cuba.

IRRIGATION AND DRAINAGE.

Agricultural Drainage.

The Development of Agricultral Drainage in Illinois and Iowa—Controlling Laws, Physical Conditions and Costs. Jacob A. Harman. Eng-Contr—May 13, 08. 5800 w. 20c. Paper read before the Iowa Drainage Association, Fort Dodge Meeting, Feb. 11 and 12, 08.

Irrigation in Egypt.

Irrigation in Egypt. Engr—Apr. 17, 08. 21 figs. 1000 w. 40c. Describes two new irrigation plants at Fadlab and Atbara.

MATERIALS.

Cement and Concrete.

Experiments to Determine Physical Characteristics of Materials to be Used in the Gatun Dam of the Isthmian Canal. Eng-Contr—May 13, 08. 1200 w. 20c.

Portland Cement: The Compounds of Lime and Silica. Cecil H. Desch. Conc & Const Eng—May, 08. 1000 w. 40c.

Tests of Coral Sand and Rock with Reference to Their Use in Concrete. Dewitt C. Webb. Eng News—May 14, 08. 800 w. 20c.

The Coefficient of Elasticity of Concrete in Shear. Cement—Apr., 08. 6 figs. 1900 w. 40c. Summary of an article by Herr Heintel in "Beton u. Eisen," in which the value of the coefficient for concrete in shear is deduced from the observed deflections of simple beams.

The Effect of Fuel Ash in Cement. Brit Clay Wkr—Apr., 08. 700 w. 40c.

The Effects of Magnesia on Cement. Brit Clay Wkr—April, 08. 1200 w. 40c.

The Electric Resistance of Mortars. Cement—Apr., 08. 1 fig. 900 w. 40c.

Steel for Reinforcing Concrete.

Immunity from Rusting of Reinforcing Steel in Concrete. Eng News—May 14, 08. 2 figs. 1200 w. 20c. Gives results of recent German Government tests.

Tests on Rusting of Steel Rods Embedded in Concrete. Eng News—May 14, 08. 700 w. 20c.

Timber.

A Review of the Present Practice and Economics of Timber Preservation. Eugene P. Schoch. St Ry Jl—May 16, 08. 4000 w. 20c. Abstract of paper read before the Southwestern Electrical & Gas Association at El Paso, Tex., May 7, 08.

The Management of the Black Locust Plantations of Pennsylvania Railroad. E. A. Sterling. Eng News—May 14, 08. 1 fig. 1800 w. 20c.

RIVERS, CANALS, HARBORS.

Breakwater.

Reinforced Concrete Caisson Breakwater at Algoma Harbor, Wis. Eng-Contr—Apr. 29, 08. 2 figs. 1200 w. 20c.

Catskill Aqueduct.

Subsurface Investigations on the Catskill Aqueduct, Board of Water Supply. Robt. Ridgway. Eng Rec—Apr. 18, 08. 2 figs. 5100 w. Apr. 25. 3 figs. 4200 w. Each 20c. Paper read before the Municipal Engineers of the City of New York.

Colorado River.

The Lower Colorado River During and After the Freshet Stage of 1907. C. E. Grunsky. Eng News—Apr. 16, 08. 1 fig. 2100 w. 20c.

Inland Waterways.

Some of the Engineering Problems Involved in the Construction of a Deep Waterway from the Great Lakes to the Gulf of Mexico. J. A. Ockerson. Eng News—May 14, 08. 6200 w. 20c. Condensed from a paper read before the Engineers' Club of St. Louis, Feb. 5, 08.

The Further Improvement of Our Inland Waterways. Maj. S. C. Riche. Eng Rec—Apr. 25, 08. 3600 w. 20c. Paper read before the Contemporary Club of Davenport, Iowa.

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Experimental Work at the Gatun Dam Site. Caleb Mills Saville. Eng News—Apr. 23, 08. 1200 w. 20c. From the "Canal Record" of April 8.

Right-of-Way on Great Lakes.

The Right-of-Way of the Great Lakes. F. C. Shenehon. Jl of Assn Eng Soc—Mar., 08. 7000 w. 40c. Paper read before the Detroit Engineering Society, Jan. 16, 08. Discusses the Great Lakes viewed as the right-of-way of a transportation system.

Sea Defenses.

Reinforced Concrete Sea Defences. H. Huisman. Conc & Const Eng—May, 08. 10 figs. 1400 w. 40c. Dutch Examples.—III. Concluded.

The Concrete Sea-Wall at Cebu, Philippine Islands. H. F. Cameron. Eng Rec—Apr. 25, 08. 4 figs. 2600 w. 20c.

Stream Flow Records.

Length of Records Necessary for Determining Stream Flow. John C. Hoyt. Eng News—Apr. 23, 08. 3500 w. 20c. Discusses what length a series of observations should have in order to determine what conditions may be expected in the future.

Water Conservation.

New York State Water-Storage and Water-Power Investigations. Eng News—Apr. 30, 08. 2300 w. 20c.

State Water Conservation and Utilization in New York and Elsewhere. Eng News—Apr. 30, 08. 2900 w. 20c.

The Relation of Water Conservation to Flood Prevention and Navigation in the Ohio River. M. O. Leighton. Eng News—May 7, 08. 1 fig. 9 tables. 13,000 w. 20c. A paper prepared as an appendix to the Preliminary Report of the Inland Waterways Commission.

SURVEYING, MENSURATION.

Mensuration of Small Angles, etc.

The Mensuration of Small Angles and Minute Lengths. John G. A. Rhodin. Engr—Apr. 24, 08. 9 figs. 3100 w. 40c.

Photo-topographic Work.

The Panoramic Camera Applied to Photo-topographic Work. Charles W. Wright. Eng News—May 14, 08. 8 figs. 4100 w. 20c. Paper presented before annual meeting of the American Institute of Mining Engineers, Toronto, July, 1907.

Preliminary Survey.

The Preliminary Survey Work on the Cut Through the Bernese Alps, and on the Lötschberg Railway. C. Koppe. Organ f. d. Fortschritte d. Eisenbahn—Apr. 1, 08. 2 figs. 2500 w. 80c.

Railroad Curves.

Compensation of Grades on Curves. Eng News—Apr. 16, 08. 2500 w. 20c. Gives data from the existing practice of several railways.

Railroad Curves. H. V. Norford. Elec Tr Wkly—May 14, 08. 4 figs. 1700 w. 20c. Gives instructions and tables for the use of trackmen.

ECONOMICS AND EDUCATION

Cost Accounting.

Accounting Literature. Leo Greendlinger. Jl Acctcy—Apr., 08. 6000 w. 40c. Gives a large list of books, on accounting, auditing, cost keeping, depreciation, etc., with brief descriptive notes regarding their contents.

A Practical Foundry Cost System. Fdry—May, 08. 5600 w. 20c. Describes the cost-keeping methods used in the foundry of the Goulds Mfg. Co., Seneca Falls, N. Y.

Isolated Station Records and Cost Accounting. G. F. Gebhardt. Power—Apr. 28, 08. 3 figs. 5500 w. 20c. Describes the system of cost accounting employed in a large private isolated power plant at Chicago, with charts and diagrams.

Labor-Cost Distribution at the General Electric Shops, Lynn, Mass. Geo. F. Stratton. Eng Mag—Mar., 08. 5 figs. 3200 w. 40c. Describes systems at a plant having 11,000 employees drawing a total of $150,000 weekly.

Obtaining Actual Knowledge of the Cost of Production. F. E. Webner. Eng Mag—May, 08. 2500 w. 40c. I.—What constitutes a knowledge of costs.

The Duties of the Navy Civil Engineers, and Their System of Keeping Cost Accounts. L. F. Bellinger. Corn Civil Engr—Apr., 08. 4 figs. 6800 w. 40c.

Cost Data, Use and Abuse of.

The Use and Abuse of Cost Data. W. W. Patch. Eng News—Apr. 30, 08. 1500 w. 20c. Points out a number of omissions often made by compilers of cost data, which render calculations based on their use unreliable.

Engineer and Banker, Relation Between.

The Relation Between Banker and Engineer. J. C. Kelsey. Ry Age—Apr. 24, 08. 900 w. 20c. Abstract of address delivered before the Western Society of Engineers, Chicago, Apr. 10, 08.

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Engineering Literature.

The Making of Literature for Engineers. Charles Whiting Baker. Eng News—Apr. 16, 08. 6500 w. 20c. An address by the managing editor of "Engineering News," delivered Mar. 27, 08, before the engineering students of the University of Michigan. Discusses the voluminosity of engineering literature, and the need for specialization and condensation, setting forth the standards and requirements of high-grade engineering journals.

Engineers as Members of Commissions.

Concerning Engineers as Members of Commissions. Eng News—Apr. 16, 08. 1300 w. 20c.

English; Its Importance to Engineers.

The Importance of English in the Work of the Engineer. Wm. D. Ennis. Eng Mag —May, 08. 2400 w. 40c.

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Executive Control in the Factory. Hugo Diemer. Factory—Apr., 08. 4 figs. 2900 w. 40c. Discusses methods of summarizing facts at the executive desk, typewritten reports, tabulated statements, graphic analyses, etc.

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Maximum Production Through Organization and Supervision. C. E. Knoeppel. Eng Mag—May, 08. 5400 w. 40c. II.—Systematic Processing, Machining, Assembly and Erection.

Running a Factory by Schedule. Robert Daily. Factory—Apr., 08. 3200 w. 40c. VI.—Foundry schedules by pay-roll periods.

Storing, Issuing and Accounting for Material. Oscar E. Perrigo. Ir Tr Rev—May 7, 08. 14 figs. 4300 w. 20c.

Suggestions for Increasing the Efficiency of Skilled Workmen. Oscar E. Perrigo. So Mach—May, 08. 2 figs. 300 w. 20c.

The Fundamental Principles of Works Organization and Management. P. J. Darlington. Eng Mag—Mar., 08. 5000 w. 40c. First of two articles devoted to the sorting and classifying of the special methods and systems used in a large number of shops.

The Management of Engineering Workshops. Eustace Thomas. Elec Engr—Apr. 24, 08. 5300 w. 40c. Paper read before the Institution of Electrical Engineers.

The Production System of the Westinghouse Elec. & Mfg. Co. H. N. Wharton. Eng Mag—Mar., 08. 2 figs. 4200 w. 40c.

Franklin Institute, Work of.

The Franklin Institute: Its Services and Deserts. Dr. Persifor Frazer. Jl Frank Inst—Apr., 08. 20 figs. 14,400 w. 60c. A lecture delivered before the Franklin Institute, Feb. 14, 08.

Industrial Conditions and Prospects.

Conditions and Prospects in the American Industry. Edwin C. Eckel. Eng Mag—Mar., 08. 1 fig. 4500 w. 40c.

Insurance.

Electricity as Viewed by the Insurance Engineer. Should the A. I. E. E. Interest Itself in Fire Protection? C. M. Goddard. Proc. Amer Inst E E—May, 08. 2200 w. 80c. A paper to be presented at the 25th annual convention of the American Institute of Electrical Engineers, Atlantic City, N. J., June 29-July 2, 08.

Mechanical Engineering Practice.

Mechanical Engineering as Practiced on the Atlantic and Pacific Coasts. George W. Dickie. Jl Assn Eng Soc—Mar., 08. 3900 w. 40c. Paper read before The Technical Society of the Pacific Coast, Jan. 24, 08.

Patents.

Notes on Patent Procedure. F. W. Blair. Elec Rev—Apr. 1, 08. 3200 w. 20c.

Safety Devices.

Reducing the Accident Risk. F. M. Feiker. Factory—Apr., 08. 13 figs. 2500 w. 40c. Presents detailed methods of accident prevention in factory construction, equipment and machinery.

Safety Appliances on Looms in Cotton Mills. Eng—Apr. 17, 08. 12 figs. 3200 w. 40c. Describes a number of protective devices used on British Mills.

The New Museum of Safety Devices at Paris. Jacques Boyer. Eng Mag—May, 08. 16 figs. 4700 w. 40c.

System for Contractor.

System in Business of General Building Contractor. Hugh Wright. Bus Man's Mag —May, 08. 14 figs. 1900 w. 20c. Describes methods used in keeping the records of extensive building operations from the estimate to the cost of the completed structure.

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ELECTROPHYSICS.

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The Alternating-Current Circle Diagram. Charles F. Smith and Wm. Cramp. Mech Engr—May 1, 08. 9 figs. 3300 w. 40c. I. Describes the use of circle diagrams for the representation of the conditions existing in alternating current circuits supplied with either constant current or constant voltage.

Electric Discharges Through Gases.

Electric Discharges through Gases. Eng—Apr. 17, 08. 2 figs. 2300 w. 40c. Concluding lecture of course on the above subject, delivered at the Royal Institution by Prof. J. J. Thomson.

Positive Electricity.

Positive Electricity. Eng—Apr. 17, 08. 4 figs. 2000 w. 40c. Lecture at the Royal Institution by Prof. J. J. Thomson, discussing the nature of positive electricity and examining whether it exhibited anything approaching in simplicity to the individual negative charges or "corpuscles."

Power Factor, Three-Phase.

Three-Phase Power Factor. Austin Burt. Proc Amer Inst E E—May, 08. 5 figs. 3800 w. 80c. A paper to be presented at the 25th annual convention of the American Institute of Electrical Engineers, Atlantic City, N. J., June 29-July 2, 08. Derives from various relations that exist between the electromotive forces and currents in a 3-phase delta-connected system, a general expression which will enable the mean power-factor to be determined exactly and develops a method by which the required values employed in the above expression may be readily determined from the standard switchboard instruments.

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Operation of Polyphase Induction Motors. R. H. Fenkhausen. Power—May 5, 08. 4 figs. 2400 w. 20c. Gives practical information in regard to treating of auto-starters, motor installation, causes of short-circuit, etc.

The Single-Phase Commutator-Type Motor. B. G. Lamme. Proc Am Inst E E—May, 08. 7 figs. 6500 w. 80c. A paper presented at a meeting of the Philadelphia Section of the American Institute of Electrical Engineers, Philadelphia, Pa., Feb. 10, 08.

Alternators.

Application of Fractional Pitch Windings to Alternating Current Generators. Jens Bache-Wiig. Proc Am Inst E E—May, 08. 4 figs. 2200 w. 80c. A paper to be presented at the 25th annual convention of the American Institute of Electrical Engineers, Atlantic City, N. J., June 29-July 2, 08.

Modern Development in Single-Phase Generators. W. L. Waters. Proc Am Inst E E—May, '08. 3 figs. 2300 w. 80c. A paper to be presented at the 25th annual convention of the American Institute of Electrical Engineers, Atlantic City, N. J., June 29-July 2, 08.

The Magnetomotive Force of Polyphase Windings. B. C. Dennison. Sibley Jl of Eng—Apr., 08. 7 figs. 3300 w. 40c. Gives formulas and method for calculation.

Theory and Practice in the Parallel Operation of Alternators. L. Fleischmann. Elek u Masch—Apr. 19, 08. 3 figs. 3500 w. 60c.

The variation in the Voltage Curves of Single and Polyphase Generators under Load. E. Siedek. Elek u Masch—Apr. 5, 08. 16 figs. 3500 w. 60c.

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The use of a Modified Cascade System of Motor Connections for Elevators, Locomotives and Rolling Mills. A. Heyland. Elek Zeit—Apr. 2, 08. 2 figs. 3500 w. Apr. 9. 2 figs. 4800 w. Each 40c.

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Systematic Design for Direct-Current Stationary Motors. H. O. Eurich and F. P. Whitaker. Mech Engr—Apr. 10, 08. 3 figs. 4400 w. Apr. 17. 6 figs. 4700 w. Each 40c. Paper read before the Rugby Engineering Society, Mar. 12, 08.

The Mercury Arc Rectifier and Its Use With Small Direct Current Motors. W. F. Sneed. Gen Elec Rev—May, 08. 4 figs. 800 w. 20c.

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High-Speed Electrical Machinery. Gerald Stoney and A. H. Law: Mech Engr—Apr. 10, 08. 6 figs. 4000 w. Apr. 17. 5 figs. 3000 w. Each 40c. Paper read before the Institution of Electrical Engineers.

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Public Service Electrical Utilities in and Near Kokomo, Ind. C. A. Tupper. West Elecn—May 9, 08. 5 figs. 4,800 w. 20c. Illustrates what may be accomplished in building up an electric railway, lighting and power distributing system and at the same time strengthening the industrial position of an entire community.

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Automatic Telephone Systems.

A Study of Multi-Office Automatic Switchboard Telephone Systems. W. Lee Campbell. Proc Amer Inst E E—May, 08. 20 figs. 9,200 w. 80c. A paper to be presented at the 25th annual convention of the American Institute of Electrical Engineers, Atlantic City, N. J., June 29-July 2, 08. Discusses reasons which make this waste necessary or expedient in manually-operated systems and shows how it can be greatly reduced in systems employing automatic switchboards.

Cables, Their Design and Use.

The Design and Use of Telephone and Telegraph Cables. F. Tremain. Elec Rev (Lond)—Apr. 10, 08. 7 figs. 2,200 w. 40c. Abstract of a paper read before the Institution of Electrical Engineers at Newcastle-upon-Tyne, on Mar. 23, 08.

Leakage in Telephone Transmission.

The Effects of Leakage and the Use of Heavisides' Distortionless Condition in Telephone Transmission. B. S. Cohen. Elecn—Apr. 10, 08. 1 fig. 1,000 w. 40c.

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Radiotelegraphy and Radiotelephony by Undamped Waves. Engg—Apr. 24, 08. 7 figs. 5,700 w. 40c. Abstract of a lecture at the London Institute by Valdemar Poulsen.

Transatlantic Wireless Telegraphy. G. Marconi. Elec Engr—May 1, 08. 7 figs. 2500 w. 40c. Lecture given before the Royal Institution, Mar. 13, 08.

TESTS AND MEASUREMENTS.

A.-C. Instruments, New.

New Alternate-Current Instruments. W. E. Spencer and J. W. Record. Elec Engr—Apr. 10, 08. 4 figs. 4,300 w. 40c. Concluded.

Arcing Grounds.

Tests with Arcing Grounds and Connections. Ernst J. Berg. Proc. Amer. Inst. E. E.—May, 08. 15 figs. 2,200 w 80c A paper to be presented at the 25th annual convention of the American Institute of Electrical Engineers, Atlantic City, N. J., June 29-July 2, 08. Describes a series of tests made in order that some mathematical expression, which would represent these phenomena with reasonable acuracy, might be deduced.

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The Installation Laboratory Testing and Repairing of Electric Meters. Joseph B. Bakes. West Elecn—Apr. 25, 08. 2,400 w. 20c. IV.—Formulas and Test Constants.

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Cables and Conductors.

A Few Unusual Burn-Outs of Underground Cables. D. W. Roper. Jl West Soc Engrs—Apr., 08. 11 figs. 7,000 w. 80c. Paper presented Dec. 13, 07, before the Western Society of Engineers.

Capacity of Cables and Conductors for Intermittent Use. R. Apt. Elek Zeit—Apr. 16, 08. 7 figs. 3,000 w. 40c.

The Manufacture and Testing of High-Tension Cables. Elec Rev (Lond)—Apr. 17, 08. 2 figs. 1,500 w. 40c.

The Mechanical Properties of Conductor Wires. G. Nicolaus. Elek Zeit—Mar. 26, 08. 3 figs. 2,500 w. 20c.

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Compensation of Pressure Variation on Alternate-Current Networks Supplying Motors. A. Heyland. Elecn—Apr. 24, 08. 14 figs. 3,000 w. 40c.

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Rules of the Society of German Electrical Engineers, 1908. W. P. Steinthal. Elec Rev (Lond)—Apr. 10, 08. 1,000 w. 40c. Abstract of paper read before the Institution of Electrical Engineers at Leeds, Mar. 19, 08.

High Tension Transmission.

Power Transmission by High-Tension Cables. R. Apt. Elec Engr—Apr. 23, 08. 3 figs. 2,800 w. 40c. Paper read before the Elektrotechnischer Verein, Berlin, Feb. 11, 08. Gives a résumé of the present state of our knowledge with regard to high-tension cables, and discusses the question as to whether power transmission by insulated cables at high pressures and over long distances is possible.

Insulators, High-Tension.

Some Notes on High-Tension Insulators for Overhead Transmission Lines. C. J. Greene. Elec Rev (Lond)—Apr. 17, 08. 2 figs. 1,600 w. Apr. 24. 1 fig. 2,100 w. May 1. 2 figs. 6,500 w. Each 40c.

Lightning Protection.

Comparative Tests of Lightning Protection Devices on the Taylor's Falls Transmission. J. F. Vaughan. Proc. Am. Inst. E. E.—May, 08. 15 figs. 5,400 w. 80c. Presented at the annual meeting of the Am. Inst. of Electrical Engrs. Furnishes data obtained on an operating line experimentally equipped with various protective devices.

Studies in Lightning Performance, Season 1907. N. J. Neall. Proc. Am. Inst. E. E.—May, 08. 6 figs. 8,300 w. 80c. Paper presented at the annual meeting of the American Institute of Electrical Engineers, New York, May 19, 08. Discusses the general import to high-tension transmission of the data gained in 1907 as to lightning performance on the Taylor's Falls lines, 50,000 volts, of the Minneapolis General Electric Co. and on the Presumpscot Electric Company feeders supplying power at 11,000 volts to the Cumberland Mills, near Portland, Me.

Switchboards.

Current Transformers as Related to Switchboard Devices. C. J. Barrow. Gen Elect Rev—May, 08. 2 figs. 1,500 w. 20c.

Electrically Operated Switchboards.—II. S. Q. Hayes. Elec Wld—May 2, 08. 6 figs. 3,400 w. 20c.

INDUSTRIAL TECHNOLOGY

Chemical Engineering.

Separating Appliances. Oskar Nagel. El Chem & Met Ind—May, 08. 15 figs. 2,300 w. 40c. Describes various types of filter presses and centrifugal separators.

The Elements of Chemical Engineering. Chem Engr—Apr., 08. 14 figs. 4,600 w. 40c. II. The conveying of solid material.

Dust Explosions.

The Dust Explosions at Minneapolis, May 2, 1878, and Other Dust Explosions. S. F. Peckham. Chem Engr—Apr., 08. 3,000 w. 40c.

Gas.

Ammonia Recovery in Connection with Producer Gas. F. J. Rowan. Ir & Cl Tr Rev—Apr. 24, 08. 8,000 w. 40c. Paper read before the West of Scotland Iron and Steel Institute.

An Improved Hygrometer for Determining the Minimum Temperature of Gas in Distribution Mains. C. C. Tutwiler. Am Gas Lt Jl—Apr. 20, 08. 1 fig. 3,000 w. 20c. Reprinted from the Journal Am. Chem. Society.

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of France. Ry Engr (Lond)—May, 08. 6 figs. 1,600 w. 40c.

Natural and Artificial Purifying Materials. Dr. L. J. Terneden. Am Gas Lt Jl—May 4, 08. 2,700 w. 20c. From the Journal of Gas Lighting.

The Air Supply and Illuminating Power of Gas-arc Lamps. H. Bunte and M. Mayer. Jl für Gasbeleuchtung—Mar. 28, 08. 3,000 w. Apr. 4. 5 figs. 5,400 w. 60c.

Glass Machine.

The Colburn Window Glass Machine. Sc Amer—May 16, 08. 6 figs. 2,900 w. 20c. Describes a novel invention for drawing window glass continuously in any width.

Paper Stock.

New Sources of Paper Stock. Arthur D. Little. Chem Engr—Apr., 08. 1,500 w. 40c.

MARINE ENGINEERING

Factors of Safety in Marine Engineering.

Factors of Safety in Marine Engineering. Prof. John O. Arnold. Engg—Apr. 24, 08. 4 figs. 3,400 w. May 1. 16 figs. 7,200 w. Each 40c. Paper read before the Institution of Naval Architects, Apr 10, 08.

Feed Pumps.

Feed Pumps for the Italian Navy. Engr—Apr. 10, 08. 2 figs. 400 w. 40c.

Lifeboats, Appliances for Manipulating.

Appliances for Manipulating Lifeboats on Sea-Going Vessels. Axel Welin. Jl Frank Inst—Apr., 08. 14 figs. 2,500 w. 60c.

"Lusitania," Speed Trials and Performance of.

Speed Trials and Service Performance of the Cunard Turbine-Steamer "Lusitania." Thomas Bell. Engg—Apr. 10, 08. 6 figs. 6,600 w. 40c. Paper read before the Institution of Naval Architects, Apr. 9, 08.

Marine Boiler Construction.

German Methods of Marine Boiler Construction.—I. Prof. Walter Mentz. Boiler Mkr—May, 08. 8 figs. 2,000 w. 20c.

"Mauretania," Electrical Equipment of.

The Electrical Equipment of the "Mauretania." W. C. Martin. Elec Engr—Apr. 9, 08. 5 figs. 2,100 w. 40c. Paper read before the Institution of Engineers and Shipbuilders in Scotland.

Ore Steamer.

The German Turret-Deck Ore Steamer "Narvik." E. Ommelange. Int Mar Engg—May, 08. 4 figs. 1200 w. 20c.

Sail Making.

Sail Making. Adrian Wilson. Int Mar Engg—May, 08. 9 figs. 5,400 w. 20c. First of three articles forming a brief treatise on the making of sails.

Salvage Dock for Submarines.

A German Salvage Dock for Submarines. Sc Am—Apr. 11, 08. 1 fig. 600 w. 20c. Describes a steel floating dock for raising sunken submarines.

Ship Construction.

A New System of Ship Construction. J. W. Isherwood. Engr—Apr. 17, 08. 2 figs. 1,500 w. 40c. Paper read before the Institution of Naval Architects, Apr. 8, 08.

Unsinkable and Uncapsizable Ships of the Goulaeff Form and System of Construction. Gen. E. E. Goulaeff. Engg—Apr. 10, 08. 33 figs. 6,400 w. 40c. Paper read before the Institution of Naval Architects, Apr. 8, 08.

Ship Propulsion.

Results of Further Model Screw Propeller Experiments. R. E. Froude. Engg—Apr. 24, 08. 7 figs. 4,000 w. May 1. 2,700 w. Each 40c. Paper read before the Institution of Naval Architects.

Ship-Model Experiments. H. Wellenkamp. Engg—Apr. 24, 08. 4 figs. 5,300 w. 40c. Paper read before the Institute of Naval Architects, Apr. 10, 08. Describes new method of research work on fluid resistance and ship propulsion.

Superheated Steam for Marine Engines.

Note on the Use of Superheated Steam with Marine Engines. Felix F. T. Godard. Engr—Apr. 17, 08. 1 fig. 1,600 w. 40c. Paper read before the Institution of Naval Architects, Apr. 8, 08.

Torpedo-Boats and Destroyers.

Modern Torpedo-Boats and Destroyers. J. E. Thornycroft. Engg—Apr. 10, 08. 13 figs. 5,000 w. 40c. Paper read before the Institution of Naval Architects, Apr. 8, 08.

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A High-Speed Air Compressor: Features of Design and Results of Tests. Eng News—May 7, 08. 9 figs. 3 tables. 2,600 w. 20c.

A Variable-Volume Air Compressor. H. V. Haight. Am Mach—Apr. 30, 08. 5 figs. 1,800 w. 20c. Describes compressor having an unloading device which varies air delivered by quarter loads and maintains full compound efficiency at all times.

Fan.

The Sirocco Fan. Power—Apr. 28, 08. 5 figs. 1,300 w. 20c. Describes an efficient fan having radially-short curved blades and capable of imparting to the air a velocity 80% above that of the circumferential velocity of the fan.

Fittings for High-Pressure Air.

Joints and Fittings for High-Pressure Air. H. V. Haight and B. C. Batcheller. Am Mach—Apr. 23, 08. 27 figs. 4,700 w. 20c. Describes screw-thread and flanged joints, and metal-to-metal contacts and packings that expand instead of blowing out.

Resistance of Air.

The Resistance of the Air and Mr. Eiffel's Experiments. Engr—Apr. 17, 08. 6 figs. 4,800 w. 40c.

FOUNDING.

Core Binders.

Core Binders. E. D. Frohman. Ir Age—May 14, 08. 2,000 w. 20c. Read before The Pittsburg Foundrymen's Association, May 4, 08.

Cupola, Care of.

Operation and Care of the Cupola. W. S. Anderson. Fdry—May, 08. 2,200 w. 20c. Discussion of present-day practice by an experienced foundryman.

Dense Castings.

The Production of Dense Castings by the Use of Deoxidizing Materials. Th. Geilenkirchen. Stahl u Eisen—Apr. 22, 08. 3200 w. 60c.

Malleable Castings.

Production of Malleable Castings. Richard Moldenke. Fdry—May, 08. 4,400 w. 20c. IV.—A discussion of malleable mixtures and the materials required including pig iron and various classes of scrap.

Metal Core-Boxes.

Difficult Metal Core-Box Work. Ethan Viall and J. K. Voelcker. Am Mach—May 14, 08. 13 figs. 2,800 w. 20c. Tells the best materials to use, special cutters, files, scrapers, chisels, etc., used. Also special chucks and appliances used on the machines.

Pipe Casting.

Casting Pipe in Permanent Molds. Edgar A. Custer. Fdry—May, 08. 13 figs. 4300 w. 20c. Describes a continuous process for making soil, water and gas pipe at the rate of 240 sections per hour.

HEATING AND VENTILATION.

Air Washing.

Air Washing and Humidifying for Industrial Purposes. Comp Air—Apr., 08. 1 fig. 3,900 w. 20c. From a paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers, by W. A. Rowe.

The Development of the Air Washer. Thomas Barwick and Saml. Kauffman. Htg & Vent Mag—Apr., 08. 11 figs. 3,100 w. 20c. A discussion at the recent annual meeting of the American Society of Heating and Ventilating Engineers.

Cost of House Heating.

Cost of Heating Residences. Prof. J. D. Hoffman. Met Wkr—May 2, 08. 1,400 w. 20c. Paper read before the Indiana Engineering Society.

Hot-Water Heating.

New Systems of Hot-Water Heating. Hr. Skopnik. Z V D I—Apr. 25, 08. 2 figs. 2,500 w. 60c. Paper read before the Alsace Lorraine Local Section of the Society of German Engineers. Describes the Goebel and Skopnik systems.

Leakage of Air Through Windows.

Testing Air Leakage Through a Window. Met Wkr—Apr. 18, 08. 3 figs. 2,200 w. 20c. Discusses a series of tests now being made on the roof of the West Street Building, New York City, a structure 23 stories high, to determine the leakage through window frames.

Mills, Heating of.

Heating Systems for Mills. Eng Rec—May 9, 08. 2,900 w. 20c. Discussion of the direct radiation, the indirect or hot blast system and forced hot-water circulation methods of heating as applied to mill buildings, in a paper presented before the National Association of Cotton Manufacturers by Mr. A. G. Hosmer.

Steam Heating.

Exhaust-Steam Versus Live-Steam Heating. Chas. A. Howard. Eng Mag—May, 08. 1,400 w. 40c. A negative argument as to the economy of heating boiler feed by live steam.

Modern Steam Heating Illustrated. B. F. Raber. Dom Engg—Apr. 18, 08. 1 fig. 600 w. 20c. IV.—The Divided Circuit System.

HOISTING AND HANDLING MACHINERY.

Belt Conveyor.

Conveyor System at the New Kleinfontein Mill. Edward J. Way. Eng & Min Jl—May 2, 08. 2 figs. 5,900 w. 20c. Describes a system of belts, some of which work on curves, others being supported from towers or mounted on turntables for handling coal, ore, ashes and waste.

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Cableways.

Characteristics of Wire Rope Tramways with Some Figures on Cost of Operation. W. S. Gemmert. Eng-Contr—Apr. 29, 08. 2,400 w. 20c. Extracts from a paper in the "Iowa Engineer," Ames, Iowa, for Jan., 08.

Formulas for the Design of Cableways. Edward B. Durham. Eng News—Apr. 16, 08. 6 figs. 4,800 w. 20c. Gives derivations of formulas used, with applications.

Crane.

An English 150-Ton Wharf Crane. Eng News—Apr. 16, 08. 1 fig. 900 w. 20c. Describes a crane for handling ships' boilers and machinery which presents some interesting features.

Derrick.

A Light, Long Steel Derrick Boom. Eng Rec—Apr. 18, 08. 3 figs. 1,000 w. 20c. Describes a steel derrick designed and used chiefly for the erection of structural steel work; of interest because of its unusual reach and lightness and for the manner in which the lead lines are taken down through the hollow mast and arranged in such a way that they cannot become fouled in any position of the boom.

Electric Hoisting Machinery.

Changes in the Design of Hoisting Machinery Due to the Adoption of Electric Power. Prof. Kammerer. Elek Zeit—Apr. 23, 08. 9 figs. 5,000 w. 40c.

Selection of Motors for Hoisting Work. R. M. Gaston. West Elecn—Apr. 25, 08. 6 figs. 1,200 w. 20c. A lecture delivered before Lewis Institute Branch of the American Institute of Electrical Engineers on Apr. 25, 08.

Elevators.

The High-Pressure Hydraulic Elevator. Wm. Baxter, Jr. Power—Apr. 21, 08. 3 figs. 1,400 w. Apr. 28. 10 figs. 2,100 w. Each 20c. Describes the construction and operation of the stop-valves in the Otis vertical and horizontal machines, also the electromagnetic devices used for operating pump.

Hoist.

Over-balance Weight for Single-drum Hoist. S. A. Worcester. Eng & Min Jl—May 2, 08. 1 fig. 1,600 w. 20c.

Shovels, Dredgers, Unloaders.

Hoisting Machinery for the Handling of Materials. T. K. Thomson. Eng Mag—May, 08. 25 figs. 4,300 w. 40c. III.—Shovels, Dredges and Special Unloaders.

HYDRAULICS & HYDRAULIC MACHINERY.

Centrifugal Pumps.

Centrifugal Pumps. I. Sibley Jl of Eng—Apr., 08. 10 figs. 3,600 w. 40c.

Hydraulic Engineering Education.

Hydraulic Engineering at the University of Wisconsin. Daniel W. Mead. Jl West Soc Engrs—Feb., 08. 15 figs. 10,000 w. 80c. Paper read Sept. 4, 07, before the W. Soc. Engrs.

Hydraulic Presses and Jacks.

Hydraulic Forging Press. Mech Engr—Apr. 24, 08. 8 figs. 2,500 w. 40c. Describes a design of hydraulic forging press worked by means of steam-hydraulic intensifier apparatus.

Modern Hydraulic Machinery. Carl Wigtel. Cass Mag—May, 08. 11 figs. 1,900 w. 40c. II.—Hydraulic Jacks and Presses.

Hydro-Electric Plants.

A Hydro-Electric Development in American Fork Canyon, Utah. A. P. Merrill. Eng Rec—May 9, 08. 3 figs. 3,200 w. 20c.

New Plants in the Mediterranean Region. Elec Rev—May 9, 08. 4 figs. 300 w. 20c. Describes a large substation of Allauch, which is designed for the supply of Marseilles, principally over a sixty-mile pole line from the Brillane hydraulic plant installed at Nice.

The Electric Power Transmission Plant of the Rurtalsperren Gesellschaft. Prof. Rasch and F. Bauwens. Z V D I—Apr. 18, 08. 29 figs. 8,500 w. Apr. 25. 13 figs. 5,500 w. Each 60c. Describes the turbines, generators and transformers of the hydroelectric plant at Heimbach, Germany, on the Rur River.

The Selection and Development of Alpine Water Powers for Electric Railroad Power Supplies.—I. W. Conrad. Zeit Oest Ing u Arch—Apr. 10, 08. 5 figs. 2,500 w. 60c.

Ice Troubles in Hydraulic Power Plants.

Ice Troubles in Hydraulic Power Work, and Methods of Overcoming Them. John Murphy. Can Engr—May 1, 08. 6 figs. 6,000 w. 20c. Address before the Applied Science Undergraduates Society of McGill Univ., Montreal, Feb. 26, 08.

Pitot Tube.

Some Pitot Tube Studies. Prof. W. B. Gregory. Proc Am Soc M E—May, 08. 9 figs., 3 tables. 3,800 w. 80c. Paper to be presented at the Detroit meeting (June 23, 08) of the American Society of Mechanical Engineers. Discusses the distribution of velocities and pressures in straight and curved portions of a six-inch water pipe.

Screw Pump, Test of.

A Test of the Screw Pump for Flushing the Kinnickinnic River at Milwaukee, Wis. Eng News—Apr. 23, 08. 1 fig. 1,300 w. 20c.

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Further Tests on the Use of Denatured Alcohol in Gasoline Engines. Eng News—Apr. 16, 08. 900 w. 20c. From data obtained at the fuel-testing plant of the Geological Survey at Norfolk, Va.

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Standard Designs and Construction of Large Gas Engines.—II. F. E. Junge. Ir Tr Rev—Apr. 16, 08. 13 figs. 4,000 w. 20c.

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A 2,000-HP. Gas Engine Blowing Unit. Machy—May, 08. 9 figs. 3,400 w. 40c. Gives details of the 2,000-HP. Westinghouse horizontal double-acting gas engine forming one of the blowing units for the Edgar Thompson Steel Works.

Tandem Gas Engine at Watson-Stillman Plant. George Malcolm. Power—May 5, 08. 8 figs. 2,900 w. 20c. Describes a double-acting tandem machine, the construction of which differs materially from the conventional type.

..Governing.

The Governing and the Regularity of Gas-Engines. James Atkinson. Engg—Apr. 17, 08. 41 figs. 8,500 w. 40c. Paper read before the Institution of Mechanical Engineers, Apr. 10, 08.

HP. Friction Losses and Efficiences.

The Horse-Power, Friction Losses and Efficiencies of Gas and Oil Engines. Lionel S. Marks. 8 figs. 3,900 w. 80c. Paper to be presented at the Detroit meeting (June 23-26, 08) of the American Society of Mechanical Engineers.

Producer Gas Plant, Test of.

Test of a Small Suction Gas Producer Plant. Prof. H. B. MacFarland. Jl West Soc Engrs—Apr., 08. 9 figs. 5,600 w. 80c. Paper presented before the Western Society of Engineers.

Springs for Gas Engine Valves.

The Design of Springs for Gas Engine Valves. F. E. Whittlesey. Machy—May, 08. 1,500 w. 40c.

Starting by Compressed Air.

The Starting of Large Gas Engines by Compressed Air. P. Meyer. Z V D I—Apr. 11, 08. 21 figs. 3,800 w. 60c.

MACHINE PARTS.

Ball Bearings.

The Factor of Safety in Ball Bearings. G. T. Rennerfelt. Am Mach—May 7, 08. 10 figs. 2,400 w. 20c. States that four balls are an advantageous number to use in a bearing and describes a new spherical roller and several bearing designs.

Belt Transmission.

Determination of the Losses in Belt Transmission. F. Niethammer and R. Czepek. Z V D I—Apr. 25, 08. 6 figs. 2,500 w. 60c.

Dynamometer Dynamo Belts. Jas. F. Hobart. Elec Wld—May 2, 08. 8 figs. 2,100 w. 20c. Gives methods whereby the power transmitted can be calculated from observation of the sag of the belt.

The Efficiency of Belt Drives. Karl Kobes. Zeit Oest Ing u Arch—Apr. 17, 08. 12 figs. 4,000 w. 60c. Mathematical study of Bach's and Gehrken's work on the subject, with diagrams, tables and illustrative examples.

Brakes and Clutches.

Clutches. Henry Souther. Proc Am Soc M E—May, 08. 47 figs. 12,600 w. 80c. Paper read May 12 in New York before the American Society of Mechanical Engineers. Describes the various forms of friction clutches with special reference to automobile requirements.

Design of Electromagnetic Brakes. J. Nikonow. Elec Wld—Apr. 18, 08. 12 figs. 3,500 w. 20c. Discusses several special points of prime importance which must be considered in connection with the design of the brake itself.

Chain Drive.

Power Transmission by Chain. Edward T. Flax. Cass Mag—May, 08. 14 figs. 3,600 w. 40c. Describes a number of chain drives and their uses.

Connecting Rods.

Dimensions of Engine Parts (connecting rod ends). E. H. Lane. Power—May 12, 08. 3 figs. 2,300 w. 20c.

Proportions of Connecting-Rod and Bearing Caps. Charles H. Lubcke. Power—Apr. 28, 08. 2 figs. 1,700 w. 20c.

Herring-Bone Gears.

Experiments with Herring-Bone Gears. C. Bach. Z V D I—Apr. 25, 08. 11 figs. 1,400 w. 60c. Shows that with accurately cut gears, transmission efficiencies as high as 94% may be attained when the pressure at the contact of the teeth is not too excessive.

Link-Belt.

The Proper Way to Use Link-Belt. Staunton B. Peck. Am Mach—May 14, 08. 11 figs. 1,100 w. 20c.

Piston Rings.

Piston Rings of Uniform Strength. W. Osborne. Am Mach—May 7, 08. 4 figs. 600 w. 20c.

MATERIALS.

Cast Iron.

The Tensile Strength of Cast Iron. F. J. Cook. Castings—May, 08. 11 figs. 11,300 w. 20c. Paper read at a meeting of the Birmingham Association of Mechanical Engineers.

Hardness.

Hardness in Steel and Its Variations. Albert F. Shore. Am Mach—Apr. 30, 08. 5 figs. 3,600 w. 20c. Describes crystal and non-crystal hardness, refractory hardness and density hardness, and real and apparent hardness caused by alloying material.

Investigations on the Hardness of Metals. —I. E. Meyer. Z V D I—Apr. 25, 08. 10 figs. 7,500 w. 60c. Describes experiments with the Brinell ball testing machine on a large number of commercial metals and alloys.

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MECHANICS.

Connecting Rods, Deflection of.

Deflection in Connecting Rods. F. Thonet. Rev d Mec—Mar. 31, 08. 1,500 w. $1.80. Mathematical proof that the deflection of a coupling rod is practically double that of a connecting rod, the same effort being transmitted.

Disks, Strength of.

Forms of Rotating Disks of Equal Strength.—I. A. Leon. Zeit Oest Ing u Arch—May 1, 08. 9 figs. 3,300 w. 60c. Mathematical study.

Eccentric Compression.

Eccentric Compression. F. Thonet. Rev d Mec—Mar. 31, 08. 3 figs. 1,000 w. $1.80. Gives method of determining the active section of a round bar compressed eccentrically, the tension in the material not being considered.

Graphical Charts.

The Construction of Graphical Charts. John B. Peddle. Am Mach—May 14, 08. 14 figs. 7,500 w. 20c. Shows how charts are plotted from equations by analyzing, substituting values and selecting scales, giving examples including an alinement chart.

Maximum Stresses in Girders.

Maximum Stresses. John S. Myers. Machy—May, 08. 4 figs. 5200 w. 40c. II.—Describes moments in two planes and crane and telpher girders.

METAL WORKING.

Annealing.

The Heat Treatment of Steel. E. R. Markham. So Mach—May, 08. 2 figs. 2600 w. 20c. III.—Annealing.

Dovetail Slides and V's, Measurement of.

Measuring Dovetail Slides, Gibs and V's. Frank H. Scheu. Am Mach—Apr. 23, 08. 17 figs. 6 tables. 1,400 w. 20c. Describes the use of wires of known diameters in the accurate measurement of male and female dovetails and V's of various angles.

Drop Forgings.

Drop and Stamped Forgings. Joseph Horner. Machy—May, 08. 29 figs. 3,600 w. 40c. Describes processes used and the methods of constructing the dies employed.

Flanging Press.

A Large Flanging Press for Boiler Sheets. Wm. J. Withem. Am Mach—Apr. 30, 08. 8 figs. 600 w. 20c. Describes a press with only two side supports on which various complicated shapes are forged.

Galvanizing.

Protection of Iron and Steel Surfaces by Means of Zinc. Sherard Cowper-Coles. Elec Chem & Met Ind—May, 08. 12 figs. 4,500 w. 40c. Résumé of the methods of protecting iron and steel and surfaces by means of zinc, given before the Glasgow Technical College Scientific Society.

Gear Cutting.

Bevel-Gear Planing Attachment for the Shaper. Am Mach—Apr. 23, 08. 2 figs. 1,000 w. 20c.

Gear-Cutting Machinery. Ralph E. Flanders. Machy—May, 08. 20 figs. 7,000 w. 40c. Continues the discussion of machines for cutting the teeth of worms and of spiral and herring-bone gears.

Gun Manufacture.

Big Gun Making in Sweden. Engr—May 1, 08. 11 figs. 3,700 w. 40c. Describes methods employed at the Aktiebolaget Bofors-Gullspäng near the western boundary of Sweden's central ore region.

Jigs and Fixtures.

Jigs and Fixtures. Einar Morin. Machy—May, 08. 12 figs. 3700 w. 40c. II.—Describes devices for guiding drills.

Leveling Planers, etc.

Precision Levels and Accurate Leveling. Am Mach—Apr. 30, 08. 9 figs. 1,300 w. 20c. Describes the setting of boring mill uprights with a novel form of level and the leveling of planers properly for accurate work by means of suitable appliances.

Lubricants for Metal Cutting.

Lubricants Used When Machining Various Materials. S. J. Kelley. Am Mach—Apr. 30, 08. 400 w. 20c.

Machine-Shop Methods.

Detailed Instructions for Machine-Shop Methods. Holden A. Evans. Am Mach—Apr. 23, 08. 10 figs. 3,200 w. 20c. Describes a planning department which plans, routes, orders material for and controls all production at the Mare Island Navy Yard.

General Instructions for Machine-Shop Methods. Holden A. Evans. Am Mach—Apr. 16, 08. 2 figs. 4,700 w. 20c. Describes a system, the following of which develops connected reports and records of material, labor and product, and promotes efficiency.

Minting Machinery.

Mechanical Equipment of the Ottawa Mint. A. H. W. Cleave. Can Elec News—May, 08. 19 figs. 5,200 w. 20c. Paper read before the Canadian Society of Civil Engineers.

Oxy-Hydrogen Welding.

Oxy-Hydrogen Welding. Frank Koester. Elec Wld—May 9, 08. 3 figs. 2,900 w. 20c.

Spiral Rolling of Metal.

Spiral Rolling of Metal. O. Clerkenwell. Am Mach—Apr. 16, 08. 1 fig. 400 w. 20c. Describes a rolling process by which the author has successfully made solid balls, conical bullets, beaded wire, screw blanks, pointed pins in a variety of shapes, and many articles that would be impossible by any other method.

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Time Recorder for Machines.

A Time Recorder for Machine Tools. N. D. Chard. Am Mach—Apr. 16, 08. 5 figs. 1,000 w. 20c. Describes an apparatus in which lines are automatically drawn on a revolving chart, graduated in hours and minutes, which record working and idle time for any machine.

REFRIGERATION.

Brine Cooler.

Maximum Capacity Ice Tank and Brine Cooler. F. A. Rider. Cld Sto & Ice Tr Jl—May, 08. 1 fig. 700 w. 20c.

Calcium Chloride.

Calcium Chloride. S. W. Calhoun. Ice & Refrig—May, 08. 1300 w. 40c. States some advantages and disadvantages of the use of calcium chloride in place of salt for ice making or refrigeration.

SHOPS AND BUILDINGS.

Hungarian Engineering Works.

The Hungarian State Engineering Works. —II. Engr—Apr. 10, 08. 6 figs. 3,800 w. 40c.

Manufacturing Plants.

Location, Arrangement and Construction of Manufacturing Plants. George M. Brill. Jl West Soc Engrs—Apr., 08. 15 figs. 8,900 w. 80c.

Power for Factories.

Power Equipment for the Small Factory. Percival R. Moses. Eng Mag—Mar., 08. 29 figs. 6500 w. 40c. Presents the problems confronting the designer of factory equipment, and shows the more important factors which should receive consideration in determining the character of the plant so that it may do its work in the most economical way.

STEAM ENGINEERING.

Boilers.

Cement and Concrete for Boiler Settings. R. I. Blankney. Power—May 5, 08. 3 figs. 2,400 w. 20c.

Some Notes on the Boiler Blow-Off. Warren H. Miller. Eng Rec—May 9, 08. 1 fig. 2,100 w. 20c.

Some Results Due to Improvement in Boiler and Furnace Design. A. Bement. Jl West Soc Engrs—Apr., 08. 7 figs. 7,300 w. 80c. Paper presented before the Western Society of Engineers, Dec. 18, 07.

Condensers.

The Influence of Air on Vacuum in Surface Condensers. D. B. Morison. Engg—Apr. 17, 08. 13 figs. 6,600 w. 40c. Paper read before the Institution of Naval Architects, Apr. 9, 08.

Damper Regulators.

Automatic Damper Regulators. W. H. Wakeman. Elec Wld—May 2, 08. 7 figs. 1,700 w. 20c.

Feed Water and Its Heating.

Tests on Live Steam Feed Water Heating. Sydney B. Bilbrough. Power—May 12, 08. 1 fig. 4,300 w. 20c. Describes experiments conducted in South Africa to observe the heat transmission through boiler plate under varying conditions.

The Substantial Advantages of Steam-Hot Feed Water. Sydney A. Reeve. Eng Mag—May, 08. 800 w. 40c. A rejoinder to the criticism of Mr. Howard in the same number of the magazine.

Water for Economical Steam Generation. J. C. Wm. Greth. Eng Mag—Mar., 08. 8 figs. 8,000 w. 40c. Gives statistics for a large number of cases showing the saving due to the installation of proper water-softening apparatus.

Fuel.

Fuel Specifications and Contracts. Wm. D. Ennis. Eng Rec—Apr. 25, 08. 6,000 w. 20c. Discusses the "heat-unit" basis for the purchase of coal.

Fuels for Power. Prof. Vivian B. Lewes. Prog Age—May 15, 08. 6,500 w. 20c. Fourth of a series of lectures delivered before the Society of Arts, London.

Relative Value of Coal and Oil Used as Fuel. R. F. Chevalier. Jl of El Power & Gas—May 2, 08. 600 w. 20c. Gives data taken from tests made on the same type of boilers ("Parker Water Tube").

Smokeless Fuel. Prof. V. B. Lewes. Prog Age—May 1, 08. 6,900 w. 20c. Third of a series of lectures delivered before the Society of Arts, London.

Spontaneous Combustion of Coal. Prof. Arthur Lakes. Min & Min (Denver)—May 1, 08. 1 fig. 1,400 w. 20c. A paper read before the Colorado Scientific Society.

The Purchase of Coal on a Scientific Basis. John B. C. Kershaw. Cass Mag—May, 08. 3,400 w. 40c. Proposes method based on the calorific value of the fuel.

Utilization of Fuels. Prof. Vivian B. Lewes. Prog Age—Apr. 15, 08. 5,500 w. 20c. Second of a series of Cantor Lectures entitled "Fuel and Its Future," delivered before the Society of Arts, London.

Mechanical Stokers.

Mechanical Stokers. John E. Barnes. Elec Engr—May 1, 08. 3300 w. 40c. Abstract of paper read at the Institution of Mechanical Engineers Graduates' Association, Apr. 13, 08.

Power Costs.

Producing Power at Lowest Cost. William J. Lees. Factory—Apr., 08. 3 figs. 3100 w. 40c. VI.—Keeping Power House Records.

The Cost of Power in Small Units. Wm. E. Snow. Eng Mag—May, 08. 2700 w. 40c. Gives tables containing the general averages of data obtained in over thirty small power plants located in different parts of the United States.

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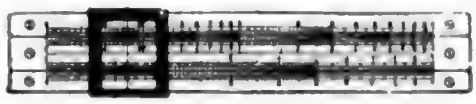

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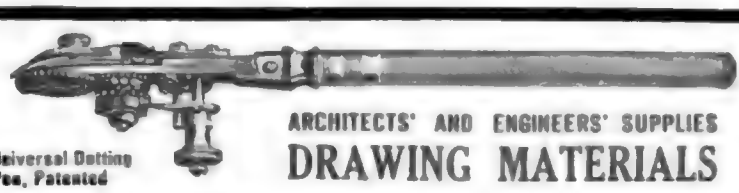

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A Handy Slide-Valve Diagram. H. J. Zelper. Power—Apr. 21, 08. 1 fig. 2300 w. 20c. Describes and illustrates a convenient diagram for laying out the movements of valves, determining the different events, and designing valves and valve-gear.

Steam.

Energy from Expansion of Steam. Prof. Sydney A. Reeve. Power—Apr. 21, 08. 4 figs. 1400 w. 20c. Gives simple charts by the use of which the energy developed by steam in expanding between given limits may be determined.

Investigations of the Pressure and Temperature drop of Saturated and Superheated Steam Flowing in Pipes. C. Eberle. Z V D I—Apr. 11, 08. 4 figs. 6000 w. Apr. 18. 5 figs. 6500 w. Apr. 25 (Concl.). 2 figs. 5500 w. with examples. Each 60c.

The Thermal Properties of Superheated Steam. Prof. R. C. H. Heck. Proc Am Soc M E—May, 08. 7 figs. 3 tables. 7600 w. 80c. Paper to be presented at the Detroit meeting (June 23-26, 08) of the American Society of Mechanical Engineers. Compares, discusses and combines the best available data in regard to the specific heat of superheated steam, to determine as nearly as may be the true value and manner of variation of that quantity, and to derive a numerical table which shall be as reliable and convenient for general use as is the ordinary table of the properties of saturated steam.

Steam Engines.

A Large Twin-Tandem Compound Direct-Connected Reversing Mill Engine. Ir Tr Rev—May 7, 08. 9 figs. 4600 w. 20c. Describes and illustrates a twin-tandem compound, condensing, direct-connected reversing engine, 20,000 HP., probably the largest and heaviest of its type built.

Engine Knocks—Their Causes and Remedies. Hubert E. Collins. Power—May 5, 08. 21 figs. 7900 w. 20c. Analyzes some of the commonest of these troubles and gives simple directions for their prevention.

Four Thousand Horsepower Engine at the Central Electric Generating Station, Brussels. Eng—May 1, 08. 2 figs. 1400 w. 40c. Gives details of a double compound tandem engine with piston valves.

Modern Steam Plants. C. Eberle. Z V D I—May 2, 08. 15 figs. 5000 w. 60c. Gives details of a number of recent steam power plants in Germany.

Steam Turbines.

Steam-Turbine Power and Transmission Plant of the Moctezuma Copper Company at Nacozari, Sonora, Mexico. John Langton and Charles Legrand. Elec Rev—Apr. 11, 08. 2 figs. 4000 w. 20c. Paper read before the Electrical Section of the Canadian Society of Civil Engineers, Mar. 5.

Steam Turbines. Rev d Mec—Mar. 31, 08. 106 figs. 8000 w. $1.80. Illustrates and describes recent designs of turbines, their lubrication, governing, etc.

Steam Turbines.—I. V. Marmor. Rev d Mec—Mar. 31, 08. 11 figs. 7000 w. $1.80. Mathematical study of the theoretical velocity of the steam flow.

The Combination System of Reciprocating Engines and Steam Turbines. C. A. Parsons and R. J. Walker. Eng—Mar. 17, 08. 18 figs. 5000 w. 40c. Paper read before the Institution of Naval Architects, Apr. 9, 08.

The Efficiency of Steam Turbines. F. A. Lart. Cass Mag—May, 08. 3400 w. 40c.

WOODWORKING.

Dry Kilns.

Dry Kilns and Dry Stock. L. C. Williams. Wood Craft—May, 08. 2300 w. 20c. From a paper read at the Chicago meeting of the National Slack Cooperage Stock Manufacturers' Association. Discusses the progress that has been made in the design and application of dry kilns.

METALLURGY

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Refractory Materials for Coke Ovens.

Refractories Used in the Construction of Coke Ovens. J. R. Campbell. Min & Min—May, 08. 4600 w. 40c. States the maximum amounts of impurities allowable for satisfactory service.

COPPER.

Blast Furnace.

The Cananea Blast Furnace. Charles F. Shelby. Eng & Min Jl—Apr. 25, 08. 16 figs. 3200 w. 20c. Gives details and drawings of a copper blast furnace, embodying the results of experience with many types in the same works.

Casting Converter Copper.

A Machine for Casting Converter Copper. J. H. Klepinger. Eng & Min Jl—May 2, 08. 2 figs. 1400 w. 20c.

Concentrator.

Three-thousand-Ton Concentrator of the Boston Consolidated Mining Company, at Garfield, Utah. Robert B. Brinsmade and R. L. Herrick. Min & Min—May, 08. 6 figs. 4600 w. 40c.

Power Plant.

The Power Plant of the New Addition of the Raritan Copper Works. Frank D. Esterbrooks. Elec & Met Ind—May, 08. 8 figs. 1800 w. 40c.

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The Great Cobar Smelting Works. Eng & Min Jl—May 9, 08. 7 figs. 3600 w. 20c. Describes an important copper-smelting plant in Australia, illustrating the latest practice, designed and partly built in the United States.

Stamp Mill.

The Calumet & Hecla Stamp Mills, Lake Superior. Robert H. Maurer. Min Wld—May 2, 08. 7 figs. 2600 w. 20c.

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Cyaniding Cripple Creek Ores. F. L. Barker. Min & Min—May, 08. 3 figs. 5000 w. 40c. (Concluded.)

The Separation of Slime in Cyanide Treatment. Horace G. Nichols. Min & Sc Pr—Apr. 25, 08. 4 figs. 3800 w. 20c.

Mill.

Goldfield Consolidated Mining Company's New Mill. Min Sc—May 7, 08. 1400 w. 20c. Describes the location, construction equipment, flow sheet and methods.

Tellurides, Treatment of.

Scorification and Supellation of Telluride Ores. George T. Holloway and Leonard E. B. Pearse. Min Wld—May 2, 08. 2200 w. 20c.

IRON AND STEEL.

Basic Open-Hearth Process.

The Basic Open-Hearth Steel Process. Achille Bosser. Mech Wld—May 1, 08. 2500 w. 40c.

China.

The Iron Industry of China. Ir Age—May 7, 08. 1 fig. 3700 w. 20c. Gives a description of the Hanyang Iron & Steel Works.

Rails, Heat Treatment of.

Heat Treatment of Steel Rails. Wm. Metcalf. Proc Eng Soc W Pa—Apr., 08. 1 fig. 4400 w. 80c. Paper read before the Eng. Soc. of W. Pa. States that the web of rail is too light and that the head of rail is too hot while flange is cold during the last passes through rolls.

Rolling Mills.

A 25,000-HP. Blooming-Mill Engine. James Tribe. Power—Apr. 21, 08. 6 figs. 3400 w. 20c. Describes features involved in the design and construction of a large horizontal twin-tandem compound reversible rolling engine at the Carnegie Steel Works, Sharon, Pa.

Electrically-Driven Reversing Rolling Mills. Henry Crowe. Elec Eng—Apr. 23, 08. 3 figs. 2500 w. 40c. Paper read on April 6, before the Cleveland Institute of Engineers.

Electric Power in Iron and Steel Mills. W. Edgar Reed. Ir Tr Rev—May 14, 08. 14 figs. 4700 w. 20c. A paper read before the Engineers' Society of Western Pa., Mar. 17, 08.

Power Requirements of Reversing Mills with Steam and Electric Drives. H. Ortmann. Stahl u Eisen—Apr. 22, 08. 3 figs. 2700 w. 60c.

The New Iron Works of the Staveley Company. Eng—Apr. 10, 08. 24 figs. 2100 w. May 1. 11 figs. 5000 w. Each 40c. Continued. Discusses the stoves, temperature-equalizers, dust-catchers, coal crushing and coke oven plants, etc.

The Electrically Driven Reversing Ingot Roll of the Georgmarienhütte. R. Wendt. Stahl u Eisen—Apr. 29, 08. 41 figs. 7500 w. 60c. Describes a newly installed roll capable of handling ingots weighing 2½ tons.

Titration.

The Influence of Copper, Arsenic and Other Foreign Metals on the Titration of Iron According to Reinhardt's Method. Stahl u Eisen—Apr. 8, 08. 4500 w. 60c.

SILVER.

Cyaniding.

Cyanidation of Silver Ore in Mexico. W. A. Caldecott. Min & Sc Pr. May 2, 08. 2 figs. 2500 w. 20c.

Development of the Cyanide Process for Silver Ore in Mexico. Bernard Macdonald. Eng & Min Jl—Apr. 18, 08. 2 figs. 2000 w. 20c.

Stamp and Cyanide Mill.

Montana-Tonopah Stamp and Cyanide Mill. Eng & Min Jl—May 9, 08. 3 figs. 1400 w. 20c. Describes mill in which the crushed ore is concentrated on Wilfley tables and vanners and the slimes are treated in Hendryx cyanide agitators.

ZINC AND LEAD.

Concentration.

Concentrating Mixed Ores at Rosas, Sardinia. Umberto Cappa. Eng & Min Jl—May 9, 08. 5 figs. 2000 w. 20c. Describes methods used for the separation of lead and zinc from mixed oxidized and sulphide ores by crushing in ball mills and washing over Ferraris tables.

Flotation.

Flotation Processes at Broken Hill. Min & Sc Pr—Apr. 11, 08. 1 fig. 800 w. 20c.

Metallurgy of Zinc.

The Metallurgy of Zinc. J. W. Richards. El Chem & Met Ind—May, 08. 5700 w. 40c. II.—Reduction of zinc oxide; electric smelting of zinc ores.

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Periodicals, Technical:

American Builders' Review, San Francisco.
Canadian Municipal Journal, Montreal, Que.
Compressed Air, New York.
Concrete Engineering, Cleveland, Ohio.
Electric Railway Review, Chicago.
Engineering-Contracting, Chicago.
Engineering News, New York.
Industrial Magazine, Park Row Bldg., New York.
Iron Age, New York.
Railway Age, Chicago.

Phonographs:

Duplex Phonograph Co., 308 Patterson St., Kalamazoo, Mich.

(Continued on page 705)

Milling.

Milling Methods in the Kansas-Missouri Zinc Fields. Doss Brittain. Min Sc—Apr. 30, 08. 2 figs. 1200 w. 20c. Gives a description of methods with a short account of the evolution from small imperfect mills to large modern plants.

Spelter.

Sampling and Assaying Spelter. Evans W. Buskett. Eng & Min Jl—Apr. 18, 08. 1200 w. 20c.

MISCELLANEOUS.

Fire Assaying.

Use of Litharge in Fire Assaying. Eng & Min Jl—Apr. 18, 08. 500 w. 20c.

Oil Concentration.

Ore Dressing, With Special Reference to Oil Concentration. El Chem & Met Ind—May, 08. 2 figs. 4300 w. 40c.

Silica, Determination of.

The Determination of Silica. Evans W. Buskett. Min Wld—Apr. 25, 08. 1100 w. 20c.

Sulphur, Determination of.

The Determination of Sulphur. Evans W. Buskett. Min Wld—Apr. 18, 08. 1100 w. 20c.

The Determination of Sulphur in Pig Iron and Steel by the Hydrogen Jet Method. Randolph Bolling. Eng News—May 7, 08. 1 fig. 2900 w. 20c.

MINING ENGINEERING

Accidents and Rescue Work.

Report on the Causes of Winding Accidents at Collieries. Prof. R. D. S. Redmayne. Mech Engr—Apr. 24, 08. 9 figs. 5500 w. 40c. Concluded. Discusses the Barrow and Rawdon colliery accidents.

Rescue Apparatus in Coal Mines. Walter E. Mingramm. Eng & Min Jl—May 2, 08. 4 figs. 1500 w. 20c. Describes the Drayer apparatus used extensively in Germany.

Rescue Work in Collieries. Coll Grdn—Apr. 10, 08. 35 figs. 8000 w. 40c. Describes the opening of a new rescue station in Lancashire and the competition trials of the various types of breathing apparatus.

The Hanna, Wyoming, Mine Disaster. R. L. Harris. Min & Min—May, 08. 6 figs. 4200 w. 40c. An account of the two explosions, the probable causes and the conditions leading up to them.

The Use of Oxygen Breathing Apparatus at the Hamstead Mine Fire. F. W. Gray. Can Min Jl—May 1, 08. 1900 w. 20c.

Three Recent Shaft Accidents. Coll Grdn—Apr. 17, 08. 13 figs. 1800 w. 40c. Continued.

Coal and Coal Mining.

A Mechanical Substitute for the Shovel in Coal Mines. W. E. Hamilton. Eng & Min Jl—Apr. 18, 08. 2 figs. 3000 w. 20c. Describes a pit-car loading machine which loads coal at about 16 cts. per ton as against 18 cts. to 40 cts. for hand loading.

A Spraying Device for Laying Dust in Coal Mines. William Clifford. Min & Min—May, 08. 5 figs. 1800 w. 40c. Describes apparatus for removing dust from its lodgments and conveying it from the mine.

Coal Washing. C. C. Myers. Sibley Jl of Engg—April, 08. 1800 w. 40c.

Dust Made in Mining Coal. C. E. Scott. Min & Min—May, 08. 1 fig. 1700 w. 40c. Gives a comparison of the amount of dust made in cutting coal by chain and by puncher machine.

Mining Coal with the Panel System. Audley H. Stow. Eng & Min Jl—May 2, 08. 2 figs. 4500 w. 20c. A discussion of operation details with reference to concentration and the reduction of working costs.

Need of Thorough Ventilation in Coal Mines. J. R. Robinson. Eng & Min Jl—May 9, 08. 1900 w. 20c. Shows from a study of a large number of colliery disasters that lack of ventilation and presence of dust are the chief causes of explosions.

Past and Future Coal Production in the United States. E. W. Parker. Min & Min—May, 08. 5 figs. 4400 w. 40c.

Submarine Coal Mining. John Johnston. Can Min Jl—Apr. 15, 08. 1200 w. 20c. Paper read before the Mining Society of Nova Scotia, Mar. 25, 08. States problems connected with developing the coal-bearing strata along the eastern seaboard of Cape Breton.

The Coal and Lignite Deposits of Montana. Jesse P. Rowe. Min Wld—Apr. 25, 08. 3 figs. 3100 w. May 2. 3 figs. 2000 w. Each, 20c.

The Effect on Coal of Water and Fine Crushing. H. M. Chapman and Edwin Barnhart. Iron Age—May 7, 08. 1 fig. 2000 w. 20c.

The Systematic Development of a Coal Mine. William Leckie. Eng & Min Jl—Apr. 25, 08. 3 figs. 3600 w. 20c. Describes an irregular bituminous seam at Pocahontas, Va., where the various problems of mining haulage and ventilation have been effectively co-ordinated.

Concrete in Mining.

Notes on the Use of Concrete in Mines.—II. Conc & Const Eng—May, 08. 12 figs. 1500 w. 40c.

Copper, Cost of.

Cost of Lake Superior and Montana Copper. James R. Finlay. Eng & Min Jl—Apr. 25, 08. 6000 w. 20c. States that conditions

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Sutton, Frank E. E.....711

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Gold.

Black Sand Tests. John M. Nichol. Mines & Min (Denver)—Apr. 24, 08. 3000 w. 20c.

Gold Camp, Rawhide.

Rawhide, Nevada. Algernon Del Mar. Eng & Min Jl—Apr. 25, 08. 5 figs. 2100 w. 20c. Discusses the district and its geological formations.

The Gold Camp of Rawhide, Esmeralda Co., Nevada. Dr. Chas. A. Gehrmann. Min Sc—Mar. 19, 08. 2000 w. 20c. Describes the discovery and progress of a new desert Eldorado, the general geology and extent of unknown mineralized area.

Hoisting Appliances.

Skips and Gages. S. A. Worcester Min & Sc Pr—Apr 11, 08. 1 fig. 1900 w. 20c. Makes a specific comparison of a number of the important features of the two devices in practical operation with regard to their economy in ore hoisting.

Hydraulic Mining.

Hydraulic Mining in California. Maj. Wm. W. Harts. Sc Am—May 9, 08. 5 figs. 1500 w. 20c. Describes methods used in impounding the debris.

Iron.

The Moose Mountain Iron Range, Ontario. J. J. Bell. Eng & Min Jl—Apr. 18, 08. 1 fig. 800 w. 20c.

Metal Mining, Problems in.

On Some Unsolved Problems in Metal Mining. Prof. Henry Louis. Engr—May 1, 08. 4800 w. 40c. Abstract of a lecture delivered Apr. 27, 08, before the Institution of Civil Engineers.

Mining Costs.

Structural Maps and Their Use in Making Up Reports. J. E. Tiffany. Min Sc—May 7, 08. 1800 w. 20c. Discusses the advantages of topographical information in the calculating of estimates of costs of development and construction.

The Cost of Mining—General Conditions. James R. Finlay. Eng & Min Jl—Apr. 18, 08. 5500 w. 20c. Discusses the factors controlling variations, stating that low costs in mining may mean greater expenses elsewhere, and that losses of ore are often neglected.

Monazite.

The Occurrence, Production and Commercial Value of Monazite. C. D. Test. Min & Min (Denver)—2300 w. 20c. From the Colorado School of Mines Bulletin.

Oil, Prospecting for.

Prospecting in the Oil Fields of Eastern Colorado. Arthur Lakes. Min Sc—Apr. 23, 08. 1 fig. 2000 w. Recites experiences in both surface and deep boring examinations in the front Range Oil Fields, with conclusions and recommendations. Apr. 30. 1 fig. 2000 w. Each, 20 cts. Describes the oil fields west of the continental divide, enumerating five oil bearing zones.

Ore Deposits.

Formation of Mineral Veins. Sc Am—May 2, 08. 2900 w. 20c. I.—Gives an analysis of rocks and the metals extracted from them.

Tendencies in the Study of Ore Deposits. Waldemar Lindgren. Min & Sc Pr—Apr. 25, 08. 5500 w. 20c. Abstract of Presidential address delivered before the Geological Society of Washington. Dec. 19, 07.

Ore Handling.

Modern Ore Handling Machinery.—I. Walter G. Stephen. Iron Trade Rev—May 14, 08. 3 figs. 4500 w. 20c.

Sorting Ore at the New Kleinfontein Mill, Transvaal, South Africa. Edward J. Way. Eng & Min Jl—May 9, 08. 800 w. 20c.

Ore Values, Computation of.

On Certain Errors in Computing Ore Values. Henry H. Knox. Eng & Min Jl—Apr. 18, 08. 4 figs. 1200 w. 20c. Describes errors in sampling; errors due to heterogeneous composition of each block of ore and errors in computing.

Prospecting.

The Churn-Drill as a Means for Prospecting. E. E. Carter. Min & Sc Pr—Apr. 25, 08. 1000 w. 20c.

Sampling Waste.

The Problem of Sampling Mine Waste Dump. Henry S. Munroe. Min Wld—May 9, 08. 3 figs. 1900 w. 20c.

Shaft Sinking.

Methods and Cost of Sinking a Shaft on the Rand with Some Good Suggestions on Drilling. Engg-Contr—Mar. 18, 08. 3 figs. 3100 w. 20c.

Record Shaft Sinking on the Rand Gold Field. Ralph Stokes. Min Wld—Apr. 18, 08. 1 fig. 1100 w. 20c.

Sinking a Concrete-Lined Mine Shaft. Eng Rec—May 16, 08. 3 figs. 1300 w. 20c.

Stoping.

Stoping Without Timbers. Marke Ehle, Jr. Min & Min—May, 08. 2 figs. 2600 w. 40c. Discusses a method adopted to working large ore bodies used at the Homestake Mine, Lead, South Dakota.

Timbering.

Timbering Methods in Missouri-Kansas District. Otto Ruhl. Min Wld—May 2, 08. 9 figs. 2900 w. 20c. Describes methods of lacing and swinging crib to strengthen vertical shaft timbering; square-set system employed in inclined shafts, etc.

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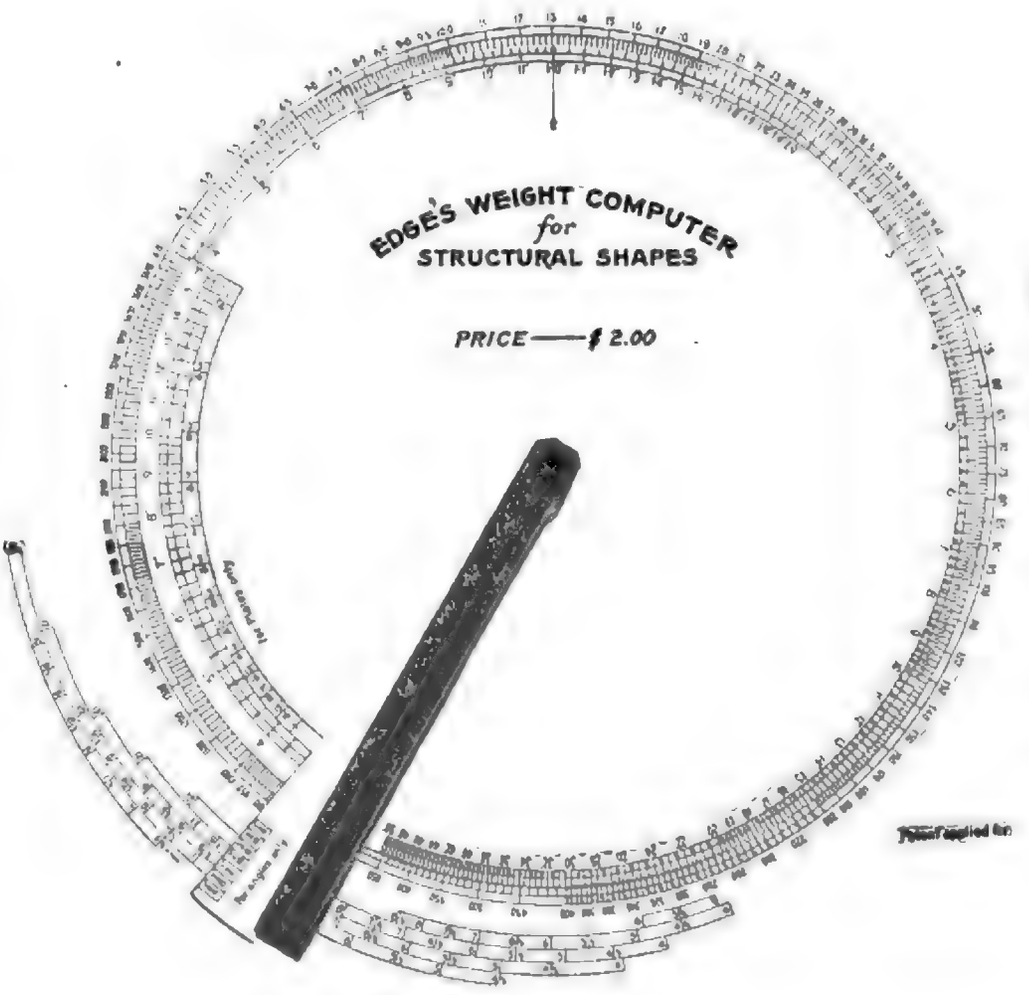

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Deep Mining Tunnels in Clear Creek County, Colorado. H. P. Dickinson. Min Sc—Apr. 16, 08. 2 figs. 1300 w. 20c. Gives a brief account of some of the larger bores, their history, methods, etc.

Zinc.

Notes on Zinc.—III. A. Humboldt Sexton. Mech Engr—Apr. 17, 08. 11 figs. 3200 w. 40c.

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Cement in Road Improvement.

The Use of Cement in Road Improvement. T. H. McDonald. Cem Era—May, 08. 1 fig. 1600 w. 20c. Paper read before the Iowa Association of Cement Users.

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Experiments with Dust Preventives on a Road at Wayland, Mass. Eng Rec—May 2, 08. 7100 w. 20c. Gives results obtained with various tar products and oil emulsions.

The Cost of Oiling Roads in New York State. Eng News—May 14, 08. 1900 w. 20c.

Paving Costs.

The Average Unit Cost of Pavement Laid in 1907 in Representative Cities, Together with the Wages of Labor and Cost of Paving Materials. Eng-Contr—Apr. 1, 08. 5200 w. 20c.

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Street Paving in London. Surveyor—Apr. 17, 08. 2900 w. 40c. Gives a brief summary of the Metropolitan Paving Committee's report.

Street Cleaning and Waste Disposal.

Automobile Street Sweepers for the City of Paris. E. Bret. Génie Civil—Apr. 28, 08. 15 figs. 4000 w. 60c. Apr. 25. 4 figs. 2500 w. 60c. Describes a self-propelled sweeper in which nebulized water is sprayed on the pavement ahead of the broom roller for the purpose of agglomerating the dust particles.

Report on Street Cleaning and Waste Disposal, New York City. Eng News—Apr. 23, 08. 7000 w. 20c. Resume of investigations extending over a period of six months, made by a commission consisting of Messrs. H. de B. Parsons, Rudolph Hering and S. Whinery.

Some Data on the Cost of Street Sweeping Taken from a Recent Report. Eng-Contr—May 6, 08. 2000 w. 20c.

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Bacteria in House Drain Pipes. Dr. F. J. H. Coutts. Mun Engg—May, 08. 2200 w. 40c.

Sewage Disposal.

Sewage Disposal Investigations by the University of Wisconsin. George Jacob Davis, Jr. Eng News—May 7, 08. 900 w. 20c.

Sewage Purification.

The New Ohio Law Governing Water and Sewage Purification and Stream Pollution. Eng-Contr—May 6, 08. 1 fig. 1800 w. 20c.

The Role of Colloids in the Purification of Sewage. J. H. Johnston. Surveyor—May 1, 08. 1600 w. 40c.

Soil Pipes.

Sizes of Soil Pipes for Dwellings. Thomas S. Ainge. Dom Engr—Apr. 25, 08. 1900 w. 20c. (Concluded.)

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Winnipeg's Experiment with Sewer Ventilation Plants. Can Engr—May 1, 08. 1 fig. 1700 w. 20c.

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Method and Costs of Cleaning Driven Wells at Lowell, Mass. Robert J. Thomas. Eng News—May 7, 08. 800 w. 20c.

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Experience with Water Pipe Incrustation at Quincy, Ill. Eng Rec—May 16, 08. 2800 w. 20c.

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Outline of the New Water Supplies for Oakland, Cal., and Other Cities on the East Shore of San Francisco Bay. Philip E. Harroun. Eng News—May 7, 08. 2 figs. 3300 w. 20c.

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Determination of the Diameter of Water Pipes Used for Extensions to Existing Plants. D. M. Rother. Jl für Gasb—Mar. 28, 08. 1 fig. 4800 w. Apr. 4, 7200 w. 60c.

Water Softening.

Operation of the Water Softening Plant at Oberlin, Ohio. Eng News—May 7, 08. 2000 w. 20c. Discusses results of a four-year trial of lime and soda ash for softening the city water.

Water Supplies from Catchment Areas.

Some Notes on Water Supplies from Catchment Areas. T. Duncanson. Water—Apr. 15, 08. 3800 w. 40c. From the Journal of the Royal Institute of Public Health, Mar. 1908.

Water Works, Statistics of.

Water Works Statistical Tables. Mun Jl & Engr—May 6, 08. 9 pages. 20c. Gives data concerning municipal and private water works plants in the U. S. and their maintenance compiled from information furnished by about 400 superintendents.

MISCELLANEOUS.

Small Parks.

The Construction of Small Parks in Chicago. Linn White. Jl W. Soc. Engrs.—Feb. 08. 11 figs. 8000 w. 80c. Paper read before the W. Soc. Engrs. Nov. 20, 07.

RAILROAD ENGINEERING

CONSTRUCTION.

Austrian Alps.

New Railway Lines in the Austrian Alps. F. Hofer. Génie Civil—May 2, 08. 16 figs. 3500 w. 60c.

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Reconstruction Work on Cincinnati, New Orleans & Texas Pacific R. R. Ry Age—Apr. 24, 08. 14 figs. 2400 w. May 1. 9 figs. 2800 w. Each, 20c.

C., C., C. & St. L. Ry.

The Improvement of a Sliding Cut on the Cleveland, Cincinnati, Chicago & St. Louis Ry. Eng News—Apr. 30, 08. 1 fig. 1200 w. 20c.

Erie R. R., Jersey City.

The New Four-Track Entrance of the Erie Railroad Into Jersey City. Eng Rec—Apr. 18, 08. 7 figs. 3300 w. 20c.

South Africa.

Location Methods on the Natal-Cape Railway, South Africa. Engg Rec—May 9, '08. 2 figs. 2300 w. 20c. Describes the methods adopted in the final survey and setting out of the line.

MANAGEMENT AND OPERATION.

Canal-Boat Transportation, Cost of.

Calculation of the Cost of Transportation of Freight by Canal Boats. Herr Block. Zent d Bau—Apr. 25, 08. 3500 w. 40c. An analysis of the elements entering into the cost of transportation, with an illustrative example employing the formulas derived.

Depreciation and Renewal of Equipment.

Railroad Equipment—Depreciation and Renewal. Wm. Mahl. Bus. Man's Mag—May, 08. 3300 w. 20c. Describes the problem of depreciation charges as applied to railroads.

Operating Expenses.

Uniformity of Operation Necessary to Uniformity of Accounts. Frank H. Crump. Ry Age—Apr. 24, 08. 2000 w. 20c. Gives the interstate commerce classification of operating expenses by departments.

Safety, Improvements Needed to Secure.

Safety in American Railway Transport. Charles A. Howard. Cass Mag—May. 08. 2900 w. 40c. Indicates lines along which improvement may be made.

POWER AND EQUIPMENT.

Coaling and Ash-handling Plants.

Notes on the Design and Performance of Locomotive Coaling and Ash-handling Plants. Wilbur G. Hudson. Eng News—Apr. 16, 08. 6 figs. 5000 w. 20c.

Draft Gear.

The Draft Gear Proposition. R. P. C. Sanderson. Ry & Eng Rev—Apr. 25, 08. 2900 w. 20c. From a paper presented at the meeting of the New York Railroad Club, Apr. 17, 08. Describes repairs required which are an important item of expense in car maintenance.

Locomotives.

Burning Lignite Coal in Locomotives. O. N. Terry. Am Engr & R. R. Jl—May, 08. 6 figs. 2200 w. 40c. Discusses the utilization of Wyoming or Northern Colorado coal in certain sections of the country in which the sub-bituminous and lignite coals are practically the only fuels available.

Combustion and Heat Balances in Locomotives. Lawford H. Fry. Engg—Apr. 10, 08. 10 figs. 13,500 w. 40c. Paper read before the Institution of Mechanical Engineers, Mar. 27, 08.

Consolidated Type Locomotive, Great Northern Railway. Am Eng & R R Jl—May, 08. 4 figs. 1000 w. 40c.

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Automatic Signaling on Locomotives. West Elecn—Apr. 18, 08. 4 figs. 1900 w. 20c. Describes systems recently tested on two English railways.

Track.

Australian Timbers for Cross Ties. C. O. Burge. Eng Rec—Mar. 21, 08. 2700 w. 20c.

Handling Rails With a Locomotive Derrick, Western Pacific Ry. Ry & Eng Rev—Apr. 18, 08. 3 figs. 900 w. 20c.

New Rail Sections and Rail Specifications of the American Railway Association. Eng News—May 14, 08. 2 figs. 4800 w. 20c.

Specifications for Bessemer and Open Hearth Rails. Iron Trade Rev—Apr. 30, 08. 4 figs. 3100 w. 20c.

Standard Tie Plates. Ry Engg & M. of Way—May, 08. 5 figs. 1900 w. 20c.

The Railway Track of the Past and Its Possible Development in the Future. J. W. Schaub. Proc. Jl W Soc Engrs—Feb. 08. 9 figs. 15,000 w. 80c. Paper with discussion read May 29, 07 before the W. Soc. of Engrs.

STREET AND ELECTRIC RAILWAYS.

Accounting.

Depreciation in Electric Railway Accounting. Daniel Royse. Elec Rev—May 2, 08. 5200 w. 20c. A paper presented at the meeting of the Iowa Street and Interurban Railway Association, Des Moines, Iowa.

The Accounting System of the Memphis Street Railway Company. St Ry Jl—May 16, 08. 3400 w. 20c.

Brakes.

The Life of Brake Shoes. G. E. Tracy. Elec Tr Wkly—Apr. 16, 08. 2 tables. 2000 w. 20c.

The Pringle Emergency Tramway Brake. Elec. Engg (Lond)—Apr. 30, 08. 5 figs. 2300 w. 40c. Describes a brake which consists of shoes or skids of iron or steel, shaped below to the profile of the upper part of the rail groove, but less deep, and provided above with a flange. These skids are hung close up to and just in front of the car wheels by a slotted link under pressure from compression springs, so that when free the skid drops into the rail groove while the wheel flange mounts the trailing end of the skid and so brings upon it the weight normally carried by the wheel.

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Electrification.

From Steam to Electricity on a Single-Track Road. J. B. Whitehead. Proc. Am. Inst. E. E—May, 08. 3 figs. 10,900 w. 80c. A paper to be presented at the 25th annual convention of the American Institute of Electrical Engineers, Atlantic City, N. J., June 29-July 2, 08. Reviews the values of impedance of the circuit consisting of trolley and track, and gives method for calculating same and suggestions as to the methods of constructing current and power curves for single-phase equipments.

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Electric Express Service at Birmingham, Ala. St Ry Jl—May 16, 08. 5 figs. 2000 w. 20c.

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230 Injectors.
232 Instruments, Surveying.
234 Insulating Materials.
236 Iron Founders.
238 Iron.
240 Jacks.
242 Jointing Materials.
246 Laborers.
248 Ladles.
250 Lamps.
252 Lathes.
254 Lighting Apparatus.
256 Lightning Conductors.
258 Lock Nuts.
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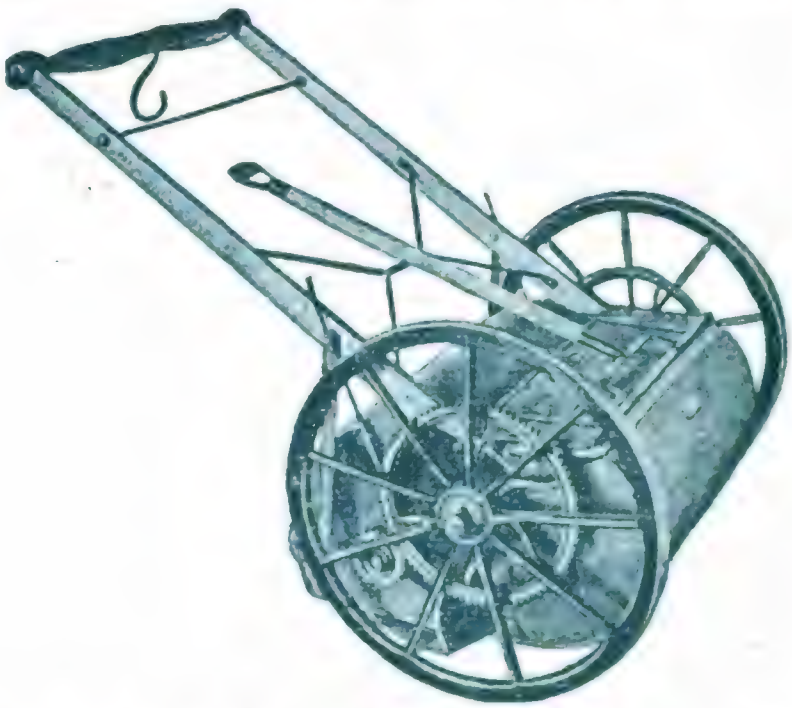

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CONTENTS

The Work of the Forest Service..... 597
Possibilities in the Electric Smelting of Iron Ores 600
The Problem of Road Construction..... 603
Notes on Motor-Car Design..... 605
Bibliography of Books and Articles on Heating, Lighting and Power Development by Means of Denatured Alcohol.. 609
The Governing and Regularity of Gas-Engines 614
The Economic Value of Water Power..... 619
Combustion and Heat-Balancing in Locomotives 621
Calculating Portland Cement Clinker..... 622
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CONTENTS (Continued)

Determining the Velocity, Size and Number of Pipes Required to Deliver a Given Quantity of Water, Under Given Conditions of Pressure and Distance 1

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing 2

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 3

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Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 6

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 7

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 8

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 9

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 10

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 11

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 12

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 13

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 14

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 15

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 16

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 17

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 18

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 19

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 20

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 21

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 22

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 23

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 24

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 25

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 26

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 27

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 28

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 29

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 30

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 31

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 32

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 33

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 34

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 35

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 36

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 37

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 38

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 39

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 40

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 41

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 42

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 43

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 44

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 45

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 46

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 47

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 48

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 49

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 50

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 51

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 52

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 53

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 54

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 55

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 56

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 57

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 58

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 59

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 60

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 61

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 62

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 63

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 64

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 65

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 66

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 67

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 68

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 69

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 70

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 71

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 72

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 73

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 74

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 75

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 76

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 77

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 78

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 79

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 80

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 81

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 82

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 83

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 84

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 85

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 86

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 87

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 88

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 89

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 90

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 91

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 92

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 93

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 94

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 95

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 96

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 97

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 98

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 99

Determining the Pressure Available at Any Point in a Pipe Line Through Which Water is Flowing (Continued) 100

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